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BIG LAGOON WETLAND AND CREEK RESTORATION PROJECT: PART II. FEASIBILITY ANALYSIS REPORT

Prepared for
Golden Gate National Parks Association

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with

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1. INTRODUCTION

The National Park Service (NPS), in collaboration with Marin County and the San Francisco Zen Center, is developing conceptual restoration design alternatives for the project site known as Big Lagoon. The Big Lagoon site includes the wetlands, floodplain, and lagoon at the mouth of Redwood Creek at Muir Beach, Marin County, California as shown on Figures 1 and 2. Big Lagoon and lower Redwood Creek have undergone significant physical and ecological changes over the last 150 years due to accelerated sedimentation from watershed disturbances, channelization and diking of the lower creek to create grazing pastures, and hydraulic constraints caused by the Muir Beach parking lot, levee road, and Pacific Way bridge. NPS retained Philip Williams and Associates, Ltd. (PWA) to develop and evaluate ecological restoration alternatives with the assistance of subconsultants, Stillwater Sciences (Stillwater), John Northmore Roberts and Associates (JNRA), and the Point Reyes Bird Observatory (PRBO). Funding for this restoration analysis has been provided through the NPS Fee Demonstration Program and a California Department of Fish and Game Coastal Salmon Recovery Fund grant.

The restoration conceptual design and evaluation is presented in two report volumes. This report constitutes Part II, the Feasibility Report, which describes conceptual restoration alternatives and assesses feasibility. Part I, the Site Analysis Report (PWA 2003), describes the physical, ecological, visitor use and cultural characteristics of the Big Lagoon project site for both historical and existing conditions.

With an understanding of the historical geomorphology and ecology of Big Lagoon and how the site has changed to its present form, a series of restoration design concepts, including the No Action Alternative, were developed given the current condition of the watershed and other opportunities and constraints. Restoration alternatives were then evaluated to answer the following key questions:

- Will the alternative be sustained by natural geomorphic processes with minimal or no human intervention?
- Does the alternative have long-term resiliency to natural processes and episodic physical disturbances?
- What are the predicted habitat types and qualities for the alternative?
- Does the alternative preserve, enhance and create suitable habitat for focus species (i.e., California red-legged frog, coho salmon, steelhead, and riparian nesting birds)?
- Can public access be accommodated within the restoration alternative?
- What is the quality of the visitor experience?

Key findings of the feasibility report are summarized in Section 2. Project objectives and site opportunities and constraints, which functioned as the framework for the alternatives development process, are presented in Sections 3 and 4, respectively. The development process and rationale for restoration alternatives and public access approaches are described in Sections 5 and 6, respectively. Each restoration alternative is evaluated in Section 7 and the public access options are assessed in Section

8. In Section 9, the restoration alternative and public access options are compared relative to the project objectives and indicators.

2. SUMMARY OF ALTERNATIVES AND CONCLUSIONS

2.1 SUMMARY OF ALTERNATIVES

Restoration alternatives were developed using a multi-objective approach, integrating ecological restoration goals with the need to provide public access. In addition to the No Action Alternative (Alternative 1), three creek and wetland restoration alternatives were identified based on our understanding of past, current, and future conceptual models of key geomorphic processes (Figures 3 through 5). The alternatives are shown in plan view and in cross-section in Figures 6 through 13 and summarized below.

<u>Alternative 1 - No Action.</u> Under the No Action Alternative, current flood management measures would continue to be implemented such as dredging Redwood Creek, maintaining the berm along Pacific Way, and possibly raising the elevation of Pacific Way. NPS would actively manage Green Gulch Creek flows to pond water and maintain existing freshwater wetland habitat. The site would remain predominantly wetland and mature riparian habitat. Channel avulsion upstream of Pacific Way Bridge would be likely, which could impede fish passage and degrade winter rearing habitat for coho salmon and steelhead. The parking lot size and location would remain unchanged.

<u>Alternative 2 – Creek Restoration</u>. Redwood Creek would be relocated eastward close to its historic (i.e., 1853) course, and a backwater channel and emergent wetland would be excavated. Artificial hydraulic constraints, such as the levee road, the south end of the parking lot, and channel bank armoring near the footbridge, would be removed. Removal of these constraints would gradually lower the groundwater surface, resulting in much of the existing wetlands being converted to riparian habitat.

<u>Alternative 3 – Creek & Small Lagoon Restoration</u>. This alternative is similar to the Creek Restoration alternative, except intermittently brackish lagoon areas, rather than backwater channel and emergent wetlands, would be excavated on either side of the creek. This alternative would provide a greater diversity of open water, wetland and riparian habitats.

<u>Alternative 4 – Large Lagoon Restoration</u>. An 8.5-acre intermittently brackish lagoon would be excavated at roughly the location of the historic lagoon. Similar to the other restoration alternatives, upstream of Pacific Way, Redwood Creek would be relocated to its historic course, and downstream of Pacific Way hydraulic constraints would be removed.

The three restoration alternatives include common design elements, such as channel realignment, removal of levee road and the south end of the parking lot, and replacement of Pacific Way bridge. These common design elements are discussed further under Section 5.3.

Various approaches to public access were developed in concert with restoration alternatives. These public access "options" are considered interchangeable with some, but not all, restoration alternatives. The key consideration for the four options is the location of the visitor parking lot.

Option A- No Action. For this option the existing 175-car parking lot and trail system would remain unchanged. Under this condition, the fill footprint for the parking lot and picnic area is 84,000 square feet. This option only corresponds to Alternative 1, the No Action Alternative.

Option B – Parking Lot at Beach. Visitor parking would remain at the existing location close to the beach. The picnic area and approximately 18,000 square feet of the parking lot would be removed, eliminating approximately 30 parking spaces. Additional fill could be placed to provide a transit turn around and/or additional parking. The minimum fill footprint would be approximately 66,000 square feet (i.e., the fill pad remaining after the picnic area and southern parking spaces are removed). The maximum fill footprint, which would accommodate a transit turnaround and parking for 200 cars, would be approximately 140,000 square feet. This public access option would be compatible with Alternatives 2 and 3. This option would not be compatible with Alternative 4 because the parking lot conflicts with the large lagoon. Accommodating parking at the beach under Alternative 4 would require reducing the area of the restored lagoon.

Option C – Parking Lot at Beach & the Alder Grove. This option retains parking close to the beach but also adds a smaller lot in the Alder Grove off Highway One, northwest of Pelican Inn. For this scenario, visitors would have the option of parking close to the beach or parking more remotely and walking the half-mile trail along the stream corridor to arrive at the beach. As for Option B, 145 cars could be accommodated on the existing fill pad after removal of the picnic area and the southern parking spaces. A total fill area of approximately 110,000 square feet would be required to accommodate a transit turnaround and 150 parking spaces. Up to 50 parking spaces would be accommodated in Alder Grove, requiring a roughly 23,000-square-foot fill pad. Similar to Option B, this option is compatible with Alternatives 2 and 3, but not Alternative 4. Accommodating parking at the beach under Alternative 4 would require reducing the area of the restored lagoon.

Option D – Parking Lot at the Alder Grove. Option D would remove the parking lot near the beach, allowing only a drop-off place, transit turnaround, and 14 disabled parking spaces. A new 118-vehicle lot would be developed at the Alder Grove, which would require a fill pad of approximately 57,000 square feet (the largest fill area compatible with the floodway in this location). Other than those dropped off by shuttle, almost all visitors would arrive at the remote Alder Grove lot and walk one-half mile to the beach along the new creekside trail. This option is compatible with all the restoration alternatives.

2.2 KEY FINDINGS

The Site Analysis, Part I of this report, provides extensive background on historic and existing conditions at the project site. Based on this information, plus additional analyses performed during the feasibility analysis, we developed the following key findings:

- Over the past 10 years, sedimentation of Redwood Creek has exacerbated flooding of Pacific Way, caused channel switching or avulsion and raised groundwater elevations within the project limits.
- The current Redwood Creek riparian corridor has important habitat value for fish, amphibians, and many bird species and mammals. In some cases, habitat requirements for salmonids and California red-legged frog are in conflict.
- The existing 175-car parking lot fill limits channel conveyance and sediment transport capacity during relatively large storm events (5-year return period or greater).
- The No Action Alternative would likely result in future increased flooding and difficult access for residents, significant annual maintenance, and potential channel avulsion and loss of fish passage.
- The large lagoon under Alternative 4 would provide the greatest improvement to flooding, initially reducing the peak water surface elevation at Pacific Way during a 50-year flood event by 2.3 feet. Alternatives 2 and 3 would provide less improvement, initially lowering the peak 50-year water surface by approximately 0.5 feet at Pacific Way.
- Although sediment delivery rates are projected to be dropping over the next several decades, they are not expected to return to pre-Euroamerican rates. Each restoration alternative, therefore, must accommodate anticipated future sediment delivery rates within the planning horizon.
- Alternative 2, a restored, self-sustaining riparian system, would accommodate future sediment delivery by increasing sediment transport to the ocean by a factor of two and providing increased floodplain area for sediment deposition.
- The small lagoons under Alternative 3, created by excavating approximately 110,000 cubic yards of sediment, could accommodate the roughly 40,000 cubic yards of sediment deposition expected within the 50-year planning horizon. By Year 50, it is expected that the small lagoons would be mostly filled, converting former open water areas to wetlands.
- Alternative 4, the Large Lagoon, provides the greatest opportunity for accommodating future sediment delivery by excavating approximately 170,000 cubic yards of sediment and allowing the system to evolve on its own. By Year 50, it is expected that roughly half of the lagoon would be filled with approximately 75,000 cubic yards of accumulated sediment.
- Under the three ecological restoration alternatives, the total extent of wetland habitat would be reduced compared to the No Action Alternative; however, the newly created wetlands would likely be more self-sustaining (supported by hydrologic and geomorphic processes) and provide higher quality, functional habitat for various focal species (i.e., California red-legged frog, coho salmon, steelhead, and riparian nesting birds). Advanced mitigation for California red-legged frog habitat may be required before excavating new wetland areas.
- The three ecological restoration alternatives provide different mixes of open water, emergent wetland and riparian habitats. Of the three alternatives, Creek Restoration under Alternative 2 would provide the greatest acreage of riparian woodlands, but the least diversity in estuarine habitats. The Creek & Small Lagoon (Alternative 3) would maintain the greatest diversity of open water, wetland, and riparian habitat types over time, as well as the largest acreage of wetland. Creation of the Large Lagoon under Alternative 4 would create a higher diversity of estuarine habitats compared to other alternatives.

- With varying success, public access, parking, and trails and preservation of the three known archeological sites can be accommodated by the restoration alternatives.
- Onsite or offsite disposal of excavated material is a key feasibility and cost issue for the restoration alternatives.

3. GOALS AND OBJECTIVES

In order to provide a clear framework for the restoration design process, we first identified an overall project strategy. We then translated the project goals provided by NPS into specific objectives, and identified qualitative and quantitative indicators for meeting those objectives. Site opportunities and constraints were also developed to guide the formulation of restoration alternatives. At each step of this process, consensus was obtained by collaborating with NPS staff and obtaining public input (through the Big Lagoon Working Group or BLWG).

3.1 PROJECT STRATEGY

The project strategy is to develop a management and restoration program that allows for the natural evolution of the landscape through geomorphic processes by anticipating and directing the seasonal and interannual patterns of flooding, sedimentation, erosion, wind-blown sand, wave action and saltwater mixing, thereby minimizing the need for human intervention, except to reconcile conflicts with desirable human activities.

In taking advantage of the natural geomorphic evolution of the site, we anticipate that we will provide the greatest opportunities to recreate native biodiversity within the ecosystem, as well as specifically provide suitable habitat for focal species within the planning horizon. Most of the habitat objectives rely on natural processes, driven by natural geomorphic evolution, to provide the desired diversity and function of individual habitat types.

This strategy is based on the following concepts of ecological integrity:

- Creeks, coastal lagoons and beaches are dynamic evolving physical systems.
- The creek and lagoon landscape at any given time is an expression of its watershed, climate, and geomorphic and ecological history.
- Similarly, the beach morphology is a function of the littoral processes—including longshore and offshore sand transport and episodic storm events—and local watershed sediment delivery.
- Physical processes tend to drive creeks toward an inherent form. So long as natural physical processes are allowed to occur, creek systems, therefore, can be self-correcting.

This strategy recognizes that there is a broad spectrum of visitor experiences compatible with the natural and cultural resources of the site that can be developed coincident with the re-establishment of natural geomorphic processes. The restoration approach will provide visitors and residents with opportunities to access natural areas in a manner that is harmonious with the long-term ecological goals of the restoration project. This will be accomplished by developing facilities that serve educational and recreational purposes appropriate to the natural and cultural setting and complementary to a healthy natural environment.

The strategy also seeks to reduce existing flooding by allowing natural geomorphic processes to shape the landscape and by modifying infrastructure to accommodate these processes. Reducing undesirable flooding of infrastructure will improve the quality of the visitor and resident experience.

3.2 PROJECT GOALS

NPS has identified the following goals for the Big Lagoon Wetland and Creek restoration project:

- Restore a functional, self-sustaining ecosystem, including wetland, aquatic and riparian components.
- Develop a restoration design that: (1) functions in the context of the watershed and other pertinent regional boundaries, and (2) identifies and, to the extent possible, mitigates factors that reduce the site's full restoration potential.
- Consistent with restoring a functional ecosystem, recreate habitat adequate to support sustainable populations of special status species.
- Reduce flooding on Pacific Way and in the Muir Beach community caused by human modifications to the ecosystem, and work with Marin County to ensure that vehicle access is provided to the Muir Beach community.
- Provide a visitor experience, public access, links to key locations, and resource interpretation that are compatible with the ecosystem restoration and historic preservation.
- Work with the Federated Indians of the Graton Rancheria to incorporate cultural values and indigenous archeological sites resources into the restoration design, visitor experience and site stewardship.
- Provide opportunities for public education and community-based restoration, including engaging local and broader communities in restoration planning and site stewardship.
- Coordinate with the Comprehensive Transportation Management Plan (CTMP) to identify transportation alternatives that are consistent with ecosystem restoration. [1]

3.3 OBJECTIVES & INDICATORS

Project objectives are specific means for achieving project goals listed above. Project objectives and indicators developed for the project are listed in Table 3.1 below. The restoration design will strive to satisfy all project objectives. However, certain objectives may be in direct conflict with each other (e.g. ecological and human use objectives), and therefore there may not be one design approach that is capable

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[1] The Comprehensive Transportation Management Plan for Southwest Marin Parklands (CTMP) is a multi-agency effort to identify and implement transportation alternatives to reduce traffic congestion and reduce the adverse environmental impacts of transportation infrastructure along the Highway 1 corridor in southwestern Marin County.

of achieving all objectives. With this in mind, conceptual design alternatives were developed with the intent of satisfying as many different objectives as possible (Sections 5 and 6). The various alternatives were then compared to evaluate the relative ability to meet project objectives (Sections 7 and 8).

Project indicators are simple metrics for measuring, either quantitatively or qualitatively, the degree to which each project objective is met. Most indicators listed below were used to provide relative ratings of alternatives' ability to meet objectives. Certain indicators were too specific to be evaluated at this conceptual design level. However, these indicators are still included to guide alternative evaluation during the EIR/EIS, future design phases and/or long-term monitoring and adaptive management.

Table 3-1. Project Objectives and Indicators

OBJECTIVES	INDICATORS
Geomorphic/Hydrologic	
1. Remove constraints to natural geomorphic processes, such as sediment transport, channel migration, channel-floodplain interaction, and seasonal and long-term beach change.	Degree that human structures (e.g., bridges, culverts, trails, parking lot, etc.) disrupt sediment transport, limit channel migration, and contribute to flooding. Width of corridor available for lateral channel migration. Areal extent of connected 1.5- to 2-year floodplain. Areal extent of connected 50-year floodplain. Width of active beach.
2. Rely on geomorphic processes to maintain and support the restoration.	Anticipated extent of future maintenance required (such as sediment removal, infrastructure maintenance, etc).
3. Accommodate future watershed sediment delivery.	Extent that future watershed sediment delivery equals sediment discharge. The rate of sediment delivery, deposition and transport is within acceptable ranges (i.e., does not diminish the performance of the restoration project).
4. Restore and accommodate natural beach processes.	Capacity of the creek to transport coarse sediment to replenish the beach. Areal extent of re-created active dune fields. Extent that the design impacts littoral transport, local littoral sediment budget, and nearshore habitat. Extent that the design accommodates beach retreat due to future sea level rise over the 50 year planning horizon. Extent that the design accommodates seasonal beach changes and infrequent extreme storm events (i.e., El Niño winter).
5. Accommodate physical disturbance (i.e. extreme hydrologic event, storm surge, sediment pulse, fires, earthquakes, etc.).	Channel conveyance capacity. Width of corridor. Width of active beach. Ability to accommodate large woody debris.
6. Restore physical complexity of creek channel.	Ability to accommodate sudden, large-scale shifts in channel location. Potential for large woody debris recruitment. Channel sinuosity or length of connected channels. Width of corridor available for lateral migration.

OBJECTIVES	INDICATORS
Ecological	
7. Improve coho salmon and steelhead winter rearing habitat.	Areal extent and quality of low velocity habitats (e.g., instream wood as flow refuge, pools, backwaters, side channels and floodplains). Complex woody debris or other types of hiding cover from predation.
8. Provide a migration corridor for steelhead and coho salmon.	Lack of potential barriers (e.g., physical barriers, water quality and temperature, water depth and velocity) from estuary to upstream project limit. Availability of pools for adult holding habitat. Continuity in landscape configuration during and immediately after implementation that allows migration.
9. Maintain or improve breeding and rearing habitat for red-legged frog (*Rana aurora draytonii)*.	Areal extent of standing water (10-100 cm deep) within emergent macrophyte stands (preferably with a range of stem diameters) during February–March to encourage oviposition. Amount of seasonal water level variation (preferred amount is 2–3 feet) to promote oviposition and upland movement by terrestrial life stages of frogs. Length of low gradient shoreline and absence of migration barriers to provide connectivity between uplands and wetlands.
10. Re-establish natural lateral and longitudinal connectivity among channel, floodplain, riparian, and upland habitats.	Length of transition zones between adjacent habitat types (e.g., channel-riparian, riparian-upland, channel-wetland, wetland-upland, wetland-riparian, dune-wetland) unimpaired by artificial structures or barriers. Length of riparian corridor (including wetlands) in different width categories (e.g., < 10 m, 10-60 m, >60m).
11. Enhance bird diversity.	Diversity of types of habitat provided (seasonal wetlands, early successional riparian habitat, mature riparian forest, intertidal wetlands).
12. Provide quality (e.g., high reproductive success) habitat for riparian/wetland-associated birds (particularly neotropical migrants).	Extent of a wide (60m-130m) riparian corridor (including wetlands). Floristic and structural habitat diversity. Presence of natural disturbance events (e.g., winter overbank flows). Reduction in nest predation pressure.
13. Enhance native dune processes and increase diversity of native dune communities.	Area of contiguous dune habitat undivided by trails. Range of dune processes and dune habitat types that will be sustained (including the active foredunes co-formed with particular native plant species, and the more stable backdune formation, characterized by a different assemblage of native plant and animal species).

OBJECTIVES	INDICATORS
14. Enhance native wetland and riparian plant assemblages.	The degree to which the wetland and riparian plant communities are supported by natural surface water, groundwater, and geomorphic processes. Natural gradient of habitat types (e.g., seasonal wetlands, to non-tidal perennial wetlands, to tidal marsh, etc.). Plant community diversity within and among habitat types (e.g., shaded riparian, seasonal wetlands, perennial wetlands, etc.) that provides native plant propagules for revegetation of patches created by natural disturbance events. Hydrologic conditions that will support appropriate disturbance regimes to promote habitat-type, age-class and plant diversity as well as structural complexity of vegetation. Floodplain inundation at an interval appropriate to balance conditions necessary for recruitment of riparian species and also prevent early die-off due to prolonged inundation. Sedimentation in wetland areas occurs at a rate appropriate to sustain the natural gradient of wetland types. Area of contiguous wetland and riparian communities undivided by trails, roads or other human structures.
15. Provide a diversity of estuarine habitats.	Diversity of aquatic habitat types (saltwater, brackish, freshwater, shallow water, deeper water, open water, submerged aquatic vegetation, emergent vegetation, intertidal habitats, etc.)
Visitor and Resident Access/Experience	
16. Engage visitors in the natural ecosystem and cultural heritage of the site.	Character and sequence of experience from vehicle to destination facilities. Character and potential of interpretive opportunities.
17. Incorporate a broad spectrum of appropriate visitor experiences compatible with resources of the site.	Variety and range of compatible (i.e., with project) visitor experiences offered. Relation of potential facilities with resources.
18. Provide convenient access to public use facilities for people of all ages and abilities.	Relative distance from parking to resource. Relationship of access route to sensitive resources Extent of compliance with ADA guidelines. Extent project exceeds ADA guidelines for special needs visitors. Consistent with CTMP recommendations for parking lot capacity, transit facilities, and trail linkages. Number of parking spaces.
19. Provide safe pedestrian access from parking/drop-off areas to public use destinations.	Number and character of road crossings. Relative amount of pedestrian traffic on Hwy. 1. Extent of trail separated from roadways. Size and character of multi-use trails.
20. Provide safe and continuous linkages between currently disconnected trails for all user groups.	Extent that linkages are provided. Number and character of road crossings. Extent of trail separation from roadways. Size and character of multi-use trails.

OBJECTIVES	INDICATORS
21. Provide safe vehicular access to the visitor resources.	Intersection function/safety. Proximity of parking access roads to intersection and view obstructions. Reduction in need or potential to park on Hwy. 1. Number of vehicular circulation decision points. Length of Pacific Way that has adequate width to allow two-way traffic.
22. Minimize access conflicts between public visitors and residential users.	Projected traffic volume on Pacific Way at residential and commercial intersections. Extent of pedestrian separation from Pacific Way. Proximity of parking to residential areas. Reduction in need or potential to park on Pacific Way.
23. Minimize land use conflicts between visitor access and adjacent uses.	Compatibility of adjacent uses. Proximity of parking. Character of linkages between uses.
24. Minimize conflicts between access and use of facilities and the natural function of the ecosystem.	Number and type of stream crossings. Proximity of sensitive habitats to access routes and use facilities. Extent of habitat connectivity. Extent that multi-use (pedestrian, bicycle, equestrian, etc.) trails are expected to cause erosion and sediment generation (due to steepness, use in the wet season, etc.).
25. Provide emergency access through site.	Ease of access to Coastal Trail south of site. Travel distance for emergency vehicles. Potential for congestion along emergency access routes. Ease of emergency vehicle access to beach.
26. Reduce noise and aesthetic/visual distraction of parking and maintain "rustic character."	Distance of parking from residents. Amount of shading/screening of parking. Size of parking bays.
27. Provide safe year-round access for Muir Beach residents.	Degree that flooding (water depth, frequency and duration) is reduced on Pacific Way and Lagoon Way.
28. Avoid adverse impacts to upstream properties that could result from channel adjustment.	Potential for bank erosion at upstream properties resulting from channel incision/migration.
29. Do not increase flood hazards to private property.	Depth of freeboard between flood elevations for individual homes and estimated peak (100-year) flood levels and storm surge runup. Potential for private properties to be impacted by channel migration and/or bank erosion.

OBJECTIVES	INDICATORS
Constructability	
30. Provide a restoration approach that can be implemented in a feasible manner.	Ability to schedule key construction activities to avoid or minimize impacts to fish and wildlife (i.e., work outside of breeding seasons, etc.). Ability to phase the project so that the areal extent of created special status species habitat equals or exceeds existing habitat. The degree to which on-site and off-site construction impacts to the community (e.g., traffic, noise, closure of access roads) are minimized. The degree to which construction impacts to park visitors (i.e. traffic, noise, parking and trail closures, etc.) are minimized. The degree to which off-site ecological impacts (e.g., due to offsite soil disposal, parking, etc.) are minimized. For phased implementation, the degree to which maintenance actions (e.g., for roads, emergency access, bridges, trails, visitor access or ecological function) will not be required during interim phases.
31. Develop a restoration plan that can be implemented in a cost effective manner.	Ability to balance cut and fill volume for earthwork. Order of magnitude costs for new/relocated infrastructure (Pacific Way Bridge, access roads, parking lot, interpretive and recreational facilities, etc.). Order of magnitude costs for adaptive management activities (including monitoring).
Cultural Resources	
32. Preserve, undisturbed, indigenous archeological sites in the project area.	Distance of ground disturbances from the archaeological sites. Degree to which archaeological sites are covered and armored to prevent erosion. Distance of potential erosion sources from archaeological sites.
33. In addition to the principle of ecological restoration, the landscape design embodies the principle of ethnographic landscape restoration and gives consideration to pertinent traditional native values.	The extent the design employs native plants with traditional Coast Miwok cultural uses. Extent to which Coast Miwok, if they so desire, are permitted to gather plant materials for traditional and interpretive uses under a special use arrangement. Extent of support by the Federated Indians of the Graton Rancheria for cultural aspects of the project design.
34. Make the project area an important focal point of interpretation of history and culture of the Coast Miwok.	The ability to provide interpretive media (visitor contact station, wayside panels, programs) that are devoted to the Coast Miwok history and use of this area.

An evaluation of geomorphic, hydraulic, ecological and constructability objectives is presented in Section 9.1, and public and resident access/experience objectives are discussed in Section 9.2. Cultural resource objectives are described in both sections as applicable.

4. OPPORTUNITIES AND CONSTRAINTS

Site opportunities and constraints were identified to serve as the foundation for alternatives development. Not all project goals and objectives are compatible, and in some cases constraints associated with public access and preservation of infrastructure conflicted with reestablishing a dynamic channel morphology and riparian corridor. Further constraints and conflicts emerged regarding the preservation, mitigation and/or creation of habitat for special status species. Buffers required around such habitats also constrained desired trail alignments and other visitor amenities.

Site opportunities and constraints are presented below by the general categories of physical, ecological, visitor and resident access and experience, and cultural resources.

4.1 OPPORTUNITIES

Physical

- The north floodplain is disconnected from Redwood Creek due to construction of the levee road. The levee road could be removed to improve floodplain connectivity.
- Much of the Green Gulch property has limited ecological function due to fill placement and past agricultural use. Artificial fill could be removed as needed to restore this area to functional riparian and/or wetland habitat.
- Excavating wetland and ponded water areas could be used to increase the sediment storage capacity of the system, allow wetland areas to evolve at a more natural rate, and increase the system's ability to respond to periodic sediment pulses.
- Over the past decade, accelerated sedimentation has resulted in increased flooding of Pacific Way. There is opportunity to reduce flood hazards on Pacific Way by restoring natural creek function and/or reconfiguring the road.
- Consolidated deposits at the downstream end of Redwood Creek may be acting as a grade control that artificially elevates the bed of Redwood Creek. Removal of this grade control could decrease sediment deposition and reduce flooding of Pacific Way and low-lying homes.
- The artificial channels draining Green Gulch are eroding and deteriorating. These channels could be enhanced to provide riparian habitat and reduce erosion. There is also opportunity to coordinate with Green Gulch Farms' future plans to restore the upstream reach of Green Gulch Creek.
- NPS and Marin County have recently intervened to reduce flooding impacts to Pacific Way (berm construction, excavation of pilot channel, etc.). Restoration of a self-sustaining geomorphic system could reduce the need for and impacts of future maintenance.
- Several restoration projects are being planned and implemented in the project area (e.g., Giacomini Ranch restoration). This project can contribute to the knowledge being gained for and by these projects.

- Restoration of the downstream end of Redwood Creek under this project will be coordinated with NPS plans for restoring the reach upstream of the Highway One bridge through the Banducci site. Implementation of this project would allow for nearly continuous restoration of roughly one mile of lower Redwood Creek.
- Flood control at the site could be evaluated in conjunction with the expansion of historic floodplains upstream of the project area, such as at the old Ballfield site, at the intersection of Highway One and Muir Woods Road.

Ecological

- The stream habitat presently provides summer rearing habitat for steelhead and salmon (except in dry years), and winter/spring rearing habitat; however, these habitats are currently degraded and fragmented. These habitats could be enhanced and reconnected to provide a diverse wetland and riparian system consisting of the creek channel and riparian wetland, ponds and freshwater wetlands, dunes, and an intermittently tidal lagoon.
- Restoration of estuarine, brackish, riparian, and freshwater habitat at Big Lagoon would create a diverse ecological system capable of supporting a wide variety of species.
- The occurrence of a small population of red-legged frogs and the former occurrence of western pond turtles indicate that the site could provide suitable habitat for these species. Increasing the area of seasonally ponded water would improve habitat conditions for these species.
- The old, buried retaining wall west of the current parking lot, apparently constructed by the operators of the former tavern, could be removed to encourage the spread of the wetter, brackish plant community dominated by salt rush (*Juncus leseurii*).
- The existence of a relatively healthy anadromous salmonid run, as well as historical evidence of larger fish populations, indicates the potential to enhance habitat for anadromous salmonids, particularly winter/spring habitat for steelhead and coho salmon.
- Creation of brackish water habitat in the lower Redwood Creek area would provide transition areas for migrating fish, allowing them to adjust to increased salinity before entering the ocean.
- The end of cattle grazing permitted the partial recovery of riparian and upland habitat with the colonization of many native plants and animals over relatively large areas of historic native landscape. There are good opportunities to continue this recovery process by passive colonization and by more active landscape management such as control of alien weeds.
- The site is currently used by wintering water birds and riparian nesting birds. Improvements to open water and/or riparian habitats could increase the capacity of the site to support diverse avifauna.

Visitor and Resident Access and Experience

- Current access and parking issues for Muir Beach visitors and residents could be resolved as part of the watershed-wide comprehensive transportation management plan.
- The project site is in a densely populated urban area and is visited by more than 400,000 people annually. Public access at the site provides an opportunity to support recreation and environmental

education for a large number of people as an actual experience of nature, not simply an experience separate from nature.

- This project offers an opportunity to restore a natural system while simultaneously developing a compatible access system for human use, interpretation, and education. Compatibly designed access can provide heightened awareness of the resources and enable the development of appropriate and insightful interpretive facilities.
- Existing management and land use practices and access systems that result in degradation to natural resources (wetlands, wildlife, water quality) could be addressed by implementing new land use and access patterns compatible with preservation and enhancement of natural resources.
- Existing conflicts between resident community and visitor uses could be addressed in ways that balance the needs while broadening and enriching the experience of both within the context of the restored natural resource. For example, visitor parking could be relocated so that traffic, noise and other impacts to residents could be reduced.
- NPS and Green Gulch Farm could enter into a partnership for stewardship of land, restoration and enhancement where mutually agreeable.
- There is opportunity to provide visitor parking at an offsite location in the lower Redwood Creek watershed that would reduce overall impacts to natural resources. If a suitable offsite parking location is identified, the onsite parking lot could be reduced in size, or possibly eliminated.
- If a shuttle bus were operated to transport visitors to Muir Beach, a stop at Green Gulch Farm could be incorporated to help alleviate parking demands at the farm during large public events.
- The resident and visitor community could participate in the restoration planning and implementation process.
- Trail connections between Muir Beach and the park trail system could be improved on the site consistent with the CTMP study currently under way. Specifically, there may be an opportunity to make a safe connection between the Diaz Ridge Trail and the Redwood Creek trail on the site. Likewise, this project may provide an opportunity to create a safe continuous linkage for the Coastal Trail between the north and south ends of the site.
- Restoration would add an educational component to the park experience related to the complex processes of wetlands restoration and the preservation of the archeological/cultural heritage of the site.
- Additional buffer zones of riparian and wetland habitat could be used to separate wildlife from recreational uses and reduce conflicts.
- Utility lines to residential homes could be relocated underground as part of the utility relocation that may be necessary for project implementation. Also, abandoned power lines could be removed.

Cultural Resources

- There is opportunity to make the park an important focal point of interpretation of history and culture of the Coast Miwok. In addition to providing opportunities for interpretive facilities, members of the Federated Indians of the Graton Rancheria could be invited to the park to deliver programs to the public.

- Native land use values at the site, such as gathering of valued plants could be revitalized.
- The Federated Indians of the Graton Rancheria could contribute to the protection of archaeological resources, revitalization of ancestral native land uses, interpretation of Native American history, and stewardship at the site.

4.2 CONSTRAINTS

Physical

- Sediment erosion rates from the watershed remain above natural (i.e., pre-colonial) background levels. The volume of sediment delivered to the site will likely affect project function and may constrain the range of feasible alternatives.
- Removal of consolidated material that is acting as a downstream grade control and/or lowering wetland elevations could cause downcutting of the Redwood Creek bed as it adjusts to the new grade. This could increase sediment erosion upstream and could possibly undercut the Pacific Way Bridge abutments and cause bank failure at private properties. Channel incision must be controlled to avoid impacts to homes and bridges along the creek.
- Large storm events will in the short-term alter the morphology of both Redwood Creek and the beach. The restored system, therefore, should be sufficiently flexible to account for dynamic changes due to flooding, sedimentation, and tidal storm surges.
- Several homes and their septic systems are situated along the creek and within the 100-year floodplain. The project cannot increase flooding of these homes or adversely affect the function of their septic systems.
- The Pacific Way crossing at Redwood Creek needs to allow natural creek function, and accommodate flood flows and allow transport of woody debris. These multiple objectives should be met in a manner that does not require significant future maintenance.
- Water is diverted from the Redwood and Green Gulch creeks at several locations upstream of the project site. These diversions may alter hydrologic conditions at the lagoon, particularly in late summer and early fall when flows in the creek are very low. Upstream water diversion changes the natural hydrologic regime, especially by reducing summer flows.

Ecological

- Low summer flows in the creek limit the potential value of the site as summer rearing habitat for steelhead and coho salmon.
- Existing habitat for special status species needs to be protected and maintained throughout project implementation, until replacement habitat is developed.
- Visitor access to the site must be provided; however, human use has potential to impact sensitive habitats (dune trampling, disturbance to nesting sites, water quality of stable runoff, etc).
- Exotic species occur throughout and along the margins of the site and will provide a continuing source of propagules to the site. Invasive exotics, therefore, need to be controlled to allow colonization by native vegetation.

- Propagules of noxious exotic species could be spread by earth-moving during implementation; any fill removed may require specific disposal plans for those areas with known invasive species.

Visitor and Resident Access and Experience

- Existing land uses onsite need to be accommodated, modified or relocated appropriately.
- Large numbers of residents and visitors currently use the site, and the visitation is expected to increase in the future. Access for those people and facilities for their daily use on the site must be provided consistent with the restoration goals for the project.
- Regional serving trails are currently discontinuous at the site, in part because of hazardous crossings at Highway One and possible conflicts with adjacent land uses.
- Access to the site for park visitors must be provided in a manner that is consistent with park policies and that provides equitable access for all types of park users.
- Some level of visitor parking must be provided either at or near the site.
- Roadway design for Pacific Way and/or any new access roads should be consistent with the recommendations of the Comprehensive Transportation Management Plan. For example, roads should be wide enough to allow two-way traffic and/or shuttle bus service but should also be designed to discourage shoulder parking.
- Congestion at the Pacific Way/Highway One intersection and conflicts between residential vehicular access to the Muir Beach community and recreational visitor access must be addressed.
- Safe access to Pelican Inn needs to be maintained.
- There are limited options for on-site and off-site earthwork disposal.
- Visitor use of the beach and the need to provide pathways to the ocean limit the extent of a contiguous dune system unbroken by trails.
- Visitor use at the beach limits potential use by shorebirds.
- Land use requirements of Green Gulch Farm need to be incorporated into restoration plans, including continued use of the eastern portion of Field 7 for horse grazing.
- Land uses near the Green Gulch Farm access should complement the function of a meditation/retreat center, particularly the rural character, quiet surroundings, operation of a farm for educational purposes, and access for the public without having large crowds.
- An access road needs to be maintained from lower Green Gulch Farm to Highway One to haul manure to the organic farm for composting.

Cultural Resources

- The two known archaeological sites within the project limits need to be preserved. Additional sites may be identified through ongoing surveys.

5. DEVELOPMENT OF ECOLOGICAL RESTORATION ALTERNATIVES

5.1 ALTERNATIVES FORMULATION

The restoration strategy (Section 3.1) guiding the formulation of alternatives recognized that the project site is a dynamic evolving landscape and that our restoration actions have to anticipate and can take advantage of the natural geomorphic processes that shape this evolution. This means that in developing a particular grading 'template' for a restoration alternative we are designing it in a way to achieve desired habitat characteristics as it evolves in response to sedimentation, floods, and sea level rise over the period of our planning horizon, 50 years in the future.

We recognize that the key factor determining how the site will evolve is the amount of sediment delivered from the watershed, and how much of it will be captured on the site. Although declining, sediment delivery rates are predicted to remain significantly higher 50 years into the future than they were under pre-Euroamerican conditions (Stillwater 2003). Whereas in the past Big Lagoon persisted and expanded because the increase in sea level outpaced sedimentation rates, now and into the foreseeable future sedimentation rates are projected to be greater than sea level rise (Stillwater 2003).

Alternative 2, termed the "Creek Restoration" alternative was therefore formulated to anticipate the eventual landscape that would ultimately evolve in this sedimentation dominated system. The site template therefore grades a creek channel and backwater areas to the natural sustainable equilibrium form.

While many features are common to all alternatives, Alternatives 3 "Creek and Small Lagoon" and 4 "Large Lagoon", reverse the impact of human induced sediment delivery by excavating lagoon wetlands in the location of the former Big Lagoon. In doing so, we recognize that these graded features will ultimately silt in and evolve to the form of Alternative 2, but over the 50 year planning horizon will provide a more diverse mix of wetland functions. These alternatives, therefore, set back the evolutionary clock. Alternative 3, whose creek channel is graded in a similar way to Alternative 2 to maximize opportunities for flood borne sediments to discharge to the ocean, would take about 100 years to evolve to the landscape of Alternative 2. Alternative 4, which recreates the functions of the original Big Lagoon, would evolve to something similar to Alternative 3 in about 50 years and to Alternative 2 in roughly 150 or more years.

5.2 DESCRIPTION OF ECOLOGICAL RESTORATION ALTERNATIVES

5.2.1 Alternative 1 – No Action

Under the No Action Alternative, Redwood Creek would remain in its current alignment, and there would be no large-scale physical modifications to the site (Figures 6 and 7). The existing parking lot, levee road and Pacific Way bridge would remain in place. Under the no action scenario, Redwood Creek would continue to aggrade, increasing the duration and extent of periodic flooding of Pacific Way and thus impacting Muir Beach visitors and residents. For these reasons, we assume that intervention would be required on an emergency basis to prevent prolonged road closures due to flooding. The No Action Alternative is based on the following assumptions:

- Periodic maintenance would continue to be performed to remove accumulate sediment and fallen trees from Redwood Creek to reduce winter flooding.

- Marin County would maintain Pacific Way at or near its current elevation and would perform periodic repaving for road maintenance.

- NPS would operate hydraulic control structures on Green Gulch Creek and the unnamed tributary to elevate groundwater levels and maintain favorable habitat conditions for red-legged frog (Section 4.3.2.1.4, Part I).

These assumptions were used to predict the performance of the No Action Alternative in the future.

5.2.2 Alternative 2 – Creek Restoration

The Creek Restoration Alternative seeks to maintain approximately the same habitat mix that currently exists, while removing hydraulic constraints and the need for ongoing maintenance. Under this alternative, approximately 2000 feet of Redwood Creek would be relocated to the low point of the valley to anticipate future channel avulsion (Figures 8 and 9). The new channel starts near the upstream project limit, traverses the Alder Grove and Green Gulch pasture and rejoins the existing creek near the downstream end of the borrow channel. The new creek would include low sloping berms to recreate the form of natural depositional levees that would occur in this reach. These low berms would confine bankfull flows and support riparian vegetation, increasing sediment transport and channel sustainability. The borrow ditch channel, which has recently captured main channel flows, would return to its function as backwater channel. To increase potential winter rearing habitat for salmonids, the backwater channel would be lengthened by excavating to the northwest.

A new bridge would be constructed along Pacific Way, centered at the new creek alignment. The new bridge would be higher and wider than the existing bridge to provide increased conveyance and sediment transport capacity. The existing channel within the relocated reach would be abandoned. Portions of the existing channel may be mechanically filled as needed to discourage fish stranding and/or create a public access trail along Pacific Way (see Section 6.2.3).

Downstream of the footbridge, the creek channel would be restored to its historic alignment along the backside of Muir Beach. The new channel will be excavated beachward in erodable sand and closer to its historic alignment based on the 1853 map and 1992 topography (PWA et al., 1994). Any artificial channel armoring would be removed by over-excavating the new channel and backfilling with sand. These improvements will allow for channel scour and improved drainage of the project site upstream in the winter months. Non-native vegetation and any remaining debris from the historic tavern would be removed to promote dune formation.

This alternative also includes removal of several hydraulic constraints. The levee road would be removed to allow lateral channel migration and reconnect Redwood Creek to the floodplain. The southeast end of the parking lot, including the picnic area, would be removed improve conveyance and sediment transport capacity. In addition, gabions and other channel armoring upstream of the footbridge that limit channel migration would also be removed.

Modifications will also be made to Redwood Creek tributaries from Green Gulch valley. Green Gulch Creek and the unnamed creek are drainage ditches that are connected to Redwood Creek via culverts through the levee road. These tributaries will be realigned to join Redwood Creek further downstream of their current culvert connections. The upstream extent of the realignment of these two tributaries is currently under consideration by NPS (see Figure 8).

Because Redwood Creek modifications are expected to lower groundwater levels, emergent wetland areas would be excavated adjacent to the tributaries. The excavated wetland area would have gradual slopes to provide suitable habitat conditions for red-legged frog under the expected range of groundwater levels.

The design basis for relocated reaches of Redwood Creek and the wetlands area are described further in Section 5.3.

5.2.3 Alternative 3 – Creek & Small Lagoon Restoration

The Creek and Small Lagoon Alternative seeks to combine riparian restoration components with open water and wetland habitats (Figures 10 and 11). This alternative includes a similar approach to the Creek Restoration alternative to improve channel conveyance and long-term sustainability of the creek. Redwood Creek would be realigned through Green Gulch pasture. In addition, two open water lagoons would be excavated on either side of the new channel. The two small lagoons would be backwaters, connected to the creek near the downstream end of the new alignment. The planform of the small lagoons is based on how the Large Lagoon would evolve to after it is roughly half-filled with sediment. Coarse sediment deposition would likely extend the lower Redwood Creek channel and levee system toward the tidal lagoon, pinching off two small oval shaped lagoons to the west and east of the channel.

The majority of the lagoon excavations would be deep enough to encourage persistence of the open water habitat. To maintain open water, emergent wetland vegetation, must be deterred from colonizing. The lagoons would have a bottom elevation of approximately (-)1 foot NGVD to maintain a minimum water depth of 3 to 4 feet year-round.

The banks of the lagoons would have varied slopes to favor a variety of habitats. In general, the lagoon on the west side of the new channel would have steeper banks to encourage riparian vegetation. This west lagoon would be excavated to connect to the borrow ditch channel, while preserving existing riparian vegetation on the west creek bank to the extent possible. The second lagoon to the east of the new channel would have gentle slopes (approximately 20:1) to promote wetland vegetation.

This alternative also includes realignment of Redwood Creek downstream of the footbridge, removal of a portion of the parking lot and levee road, installation of a new Pacific Way bridge, and realignment of Green Gulch valley tributaries, as described for Alternative 2. The design basis for these elements is provided in Section 5.3.

5.2.4 Alternative 4 – Large Lagoon Restoration

The Large Lagoon alternative seeks to create brackish influenced open water habitat similar to historic (i.e., 1853) conditions, but within existing constraints of Pacific Way and private property (Figures 12 and 13). The 1853 map shows a large open water lagoon with fringing wetlands extending to the edge of the valley immediately landward of Muir Beach (Figure 3). The large lagoon would roughly follow this orientation, except with 100-foot minimum setbacks from existing constraints of the modified parking lot footprint, Pacific Way and upland areas of Green Gulch pasture. As a result of these modern day constraints, the large lagoon would be slightly smaller than the historic Big Lagoon.

To maintain open water, the lagoon would be excavated to a bottom depth of (-) 1.0 feet NGVD to deter emergent vegetation from colonizing and allow for periodic incursions and tidal water, similar to Alternative 3. The lagoon would be excavated with gentle side slopes to encourage colonization by emergent wetland vegetation. For the conceptual design, we have assumed 10:1 slope between elevations 1 and 3 feet NGVD and 5:1 slope from 3 to 5 feet NGVD.

Upstream of the lagoon, Redwood Creek would be realigned to the low point of the valley bordered by small berms emulating natural levees. Downstream of the new lagoon, Redwood Creek would be realigned beachward similar to Alternatives 2 and 3. This alternative also includes removal of a portion of the parking lot and levee road, installation of a new Pacific Way bridge, and possible realignment of the Green Gulch tributaries.

5.3 DESIGN BASIS FOR RESTORATION ELEMENTS

The restoration alternatives have similar design approaches for improving sediment transport, removing hydraulic constraints and providing a geomorphically stable channel design. The basis of design for these common design elements is described below. The following discussion is appropriate for conceptual-level design; additional analysis would be needed to further refine these elements for design and implementation.

5.3.1.1 Redwood Creek: Configuration & Profile

The channel cross-sectional geometry and longitudinal profile were based on expected equilibrium conditions. As noted on Figure 14, the valley slope is relatively steep through Banducci (approximately

0.004) and the upstream project site and then flattens at the former Big Lagoon to about 0.002. Therefore, in all the alternatives, the slope of lower Redwood Creek is approximately equal to the average valley profile upstream from Highway One through the Banducci site (Figure 14). For this reason, the restoration alternatives are not expected to significantly affect channel stability on the Banducci site, located immediately upstream of the project site. For the creek and small lagoons alternatives, the new channel would be graded with a uniform channel slope of approximately 0.003 to provide more constant sediment transport capacity (Figure 15). For the large lagoon alternative, the new channel upstream of the lagoon could be sloped more steeply, up to approximately 0.006 (Figure 16). For all three alternatives, the tidal portion of the channel (downstream of the existing footbridge) would be sloped at approximately 0.002.

The new channel should be sized to convey bankfull flow, estimated by the 1.5-year to 2-year return period (570 to 805 cfs). Bankfull channel dimensions would be approximately 5 feet deep and 25 to 30 feet wide, based on the geomorphic and hydraulic analyses previously performed for the Banducci site (PWA, 2000). Uniform channel dimensions of 5 feet deep and 25 feet wide were used for hydraulic analyses presented in this study. More detailed geomorphic analysis should be performed at the detailed design stage to further refine channel dimensions.

The new channel would include low berms along the banks to emulate the natural depositional levees that would be expected to form at the lower end of Redwood Creek. These natural levees built up over time from deposition during overbank flood events and supported riparian vegetation, likely willows and alders. For the restoration alternatives, the constructed berms would serve several functions, including improving sediment transport, facilitating channel re-establishment and supporting riparian vegetation.

The berms would be designed to confine bankfull flows to help re-establish a self-sustaining, well-defined channel. Based on the design profile, the new channel thalweg varies between 3 and 4 feet below adjacent existing grades (see the as-built thalweg and the valley profiles in Figure 15). The berms would vary from approximately 1 to 2 feet in height as needed to produce a 5-foot deep channel. As shown on Figure 9, the berms would be a subtle feature, graded with gentle slopes to emulate a natural levee. The berms would be at the appropriate elevation to support riparian vegetation. Trees would shade the channel, reducing water temperatures for improved fish habitat, and shading out emergent vegetation. Over time, mature trees would add woody debris to the channel, enhancing complexity and fish habitat.

[If the berms were not included in the design, although the minimum depth of the initially constructed channel (roughly 2 feet), would be greater than the minimum depth required for fish passage (6 to 12 inches), the conveyance of the low-flow channel would be roughly half of bankfull flow. This would result in more frequent overbank flows and reduced sediment transport capacity. Although, the berms are expected to build up over time naturally, in the short-term, the channel bed would be more susceptible to sediment deposition and emergent vegetation establishment. These conditions would further reduce conveyance and sediment transport, leading to channel avulsion. A network of minor distributary channels may develop on the floodplain, diffusing flows and reducing fish passage.]

5.3.1.2 Redwood Creek: Upstream of Former Big Lagoon to Highway One

The main channel of Redwood Creek would be realigned closer to its historic location along the valley floor starting at the upstream project limit. For the creek and small lagoon alternatives, the new channel would traverse the Alder Grove and Green Gulch pasture and rejoin the existing creek near the downstream end of the borrow channel. For Alternative 4, the new creek would extend approximately 200 feet downstream of Pacific Way, and then flow into the large lagoon. Under each alternative, the historical channel morphology and alignment were used as a design guideline for the new alignment.

Historically, lower Redwood Creek flowed along the center of the valley (Figure 3) until it was relocated to its present position along the western edge of the valley sometime in the early 1900's. Restoring the creek to its historic alignment in the valley low point would encourage more natural channel-floodplain interaction. The new alignment is somewhat modified from the 1853 alignment due to private property buffers. In the design phase, additional geomorphic analysis may be used to further refine the channel alignment.

Upstream of Pacific Way (in the Alder Grove), the creek would be located roughly in the center of the available floodplain, to maximize the riparian buffer zone between the new channel and adjacent private properties (residences and the Pelican Inn). The channel would coincide with the valley low point except within roughly 200 feet upstream of Pacific Way. In this reach the new channel is roughly 100 feet southward of the low point to provide a 50-foot minimum buffer from the Pelican Inn. A small drainage swale would drain between the buffer area between the new channel and Pelican Inn property.

The upstream diversion point for the new channel (Figures 8, 10, and 12) was based on field observations, existing topography and the project limits. Currently the thalweg elevation of Redwood Creek is higher than the valley low point within approximately 300 feet upstream of Pacific Way (Figure 14). Further upstream, even though the thalweg is the low point, the floodplain slopes away the creek banks, so that overbank flows would tend to flow toward Green Gulch pasture rather than returning to the creek. As shown on Figure 15, the new channel begins at approximately the location where the existing channel slope flattens considerably due to recent deposition upstream of the Pacific Way bridge. To prevent channel avulsion, the new channel should be relocated as far upstream as possible, within the project limits.

5.3.1.3 Redwood Creek: Downstream of Former Big Lagoon

Under all restoration alternatives, Redwood Creek immediately upstream of the tidal lagoon would be shifted seaward of its existing location to an alignment consistent with the 1853 map and early aerial photographs of the site. The design alignment was based on 1992 topographic map (PWA et al., 1994). As described in the pre-Euroamerican conceptual model (Section 2, Part I), high flows in the winter scoured a channel along the back beach to the ocean. With the current location, channel scour is constrained by wind blown sand that accumulates in the dense willows and alders and cohesive soils.

In this area, the channel thalweg may also be constrained by remnant channel armoring. Over the years, riprap has been transported downstream and deposited in the channel, including revetment from a channel wall that collapsed in winter 1983 (PWA, 1994). To ensure that all artificial armoring is removed, the new channel would be over-excavated and backfilled with sand. This over-excavation may include removal of some cohesive soils and vegetation in the Willow/Alder Grove, if determined necessary during detailed design. These improvements would restore the historical alignment in the easily erodable sand of the back beach, encouraging channel scour and improved drainage of the project site in the winter months.

In addition, toward the west end of the beach, non-native vegetation and any remaining debris from the historic tavern would be removed to promote dune formation. Dunes are most likely to form toward the southeast end of the beach, due to the direction prevailing wind. In addition, the dunes, which have already started to form north of the tidal lagoon, will also likely expand over time once vegetation is removed. As dunes are sensitive to human trampling, fencing or other means should be employed to restrict public access to dune restoration areas.

Further restoration of the tidal lagoon was not considered in this study because of NPS's decision to preserve existing wetland vegetation. However, future enhancement of the tidal lagoon, as described in the 1994 Environmental Assessment (EA, PWA et al., 1994), would likely be compatible with all restoration alternatives. Tidal lagoon enhancement could include removal of vegetation and surface fill toward the existing parking lot. This would enlarge the lagoon habitat, and further facilitate dune formation north of the tidal lagoon. Wave action and inundation by ponded lagoon water would discourage vegetation establishment, and windblown sand would begin to build up the historic dune field (PWA et al., 1994).

5.3.1.4 Parking Lot Removal

One hydraulic criterion for restoration was to remove existing hydraulic constraints to facilitate sediment transport and reduce flooding on local roads. As described in Section 4.2.3 of Part I, the existing parking lot contributes to sedimentation in lower Redwood Creek, loss of channel capacity, and flooding of Pacific Way. Fill placement for the parking lot creates a backwater affect during flows of roughly > 2-year return period (805 cfs). Hydraulic modeling was used to evaluate the hydraulic impact of the existing parking lot and identify improvements for the restoration design.

Hydraulic modeling was employed to determine the effects of removal of parking lot fill on improving conveyance and sediment transport capacity (see Section 7.1.2 and Appendix A for discussion of modeling methods). A sensitivity analysis was performed on the existing conditions model by testing the impacts of removing a portion of existing fill. The eastern end of the parking lot and picnic area was moved westward 30, 60, 90, 120, and 300 feet. Each of these 5 parking lot configurations was tested in the hydraulic model under the Q5 and Q50 conditions. Immediately upstream of the parking lot under Q5 conditions, the hydraulic model showed that water levels dropped by 0.5 ft, 0.7 ft, and 0.9ft at setback distances of 30, 90, and 300 feet (Figure 17). A similar hydraulic pattern was apparent under Q50 conditions. The 90-foot parking lot setback was selected as an appropriate minimum parking lot setback distance, given the diminishing improvement in water levels with increasing setback distance. The relatively smooth water surface profile for the 90-foot setback indicates that parking lot removal would result in roughly uniform conveyance and sediment transport capacity. Other potential ecological impacts of the parking lot were not evaluated.

Therefore, each restoration alternative would include removal of at least the southeast end of the parking lot, including the picnic area. Approximately 2 to 3-foot depth of fill would be removed to restore natural floodplain elevations. In addition, gabions and other channel armoring upstream of the footbridge that limit channel migration would also be removed.

5.3.1.5 New Bridge at Pacific Way

As described in Section 4.2.3 of Part I, the existing Pacific Way Bridge has contributed to sedimentation in lower Redwood Creek, loss of channel capacity, and flooding of Pacific Way. Pacific Way Bridge is located on the edge of the valley, rather than the low point. In addition, the existing bridge is undersized, is not aligned with upstream flow direction, and does not allow channel-floodplain interaction. In 2002, Marin County estimated that the bridge capacity was approximately 600 cfs, insufficient to convey the 2-year peak flow of 805 cfs (Klein *et al.*, 2002). Approximately six months after NPS had dredged the bridge in September 2002, roughly half of the excavated area had been refilled due to sediment deposition.

Each restoration alternative includes a new pier-supported bridge along Pacific Way to reduce impacts to geomorphic processes. The new bridge would be centered roughly at the new channel and span the floodplain. The south end of the bridge would be near the existing bridge, and the north end would extend to the Pelican Inn property. Given these end constraints, the maximum length of the bridge would be approximately 300 feet.

Hydraulic modeling of the 50-year flood event was used to determine the effects of the new bridge on the water surface upstream of Pacific Way and to determine the minimum width of the bridge that has insignificant effects on upstream water surface elevations. A sensitivity analysis was performed to evaluate the hydraulic effects of shortening the bridge length. The hydraulic model for Alternative 2 was used for this analysis, because this alternative has the highest water surface profile. Several bridge spans and pier spacings were modeled to determine the relative increase in the upstream water surface. The relative water surface increase based on narrowing the bridge opening is summarized in Table 5-1. It should be noted that this a conceptual-level sensitivity analysis, based on an uncalibrated hydraulic model (described further in Section 7.1.1 and Appendix A). During the detailed design phase, the bridge design should be refined using a calibrated hydraulic model. Based on our preliminary hydraulic analysis, the soffit (bottom of bridge deck) of a 240-foot long bridge for Alternative 2 should be at approximately elevation 16.5 feet NGVD, based on the 50-year water surface and one-foot freeboard. For Alternatives 3 and 4, the soffit elevation could be lower corresponding to the lower water surface elevation.

The bridge width would also be determined during future design phases. At this stage, the minimum bridge width is assumed to be 28 feet to allow mixed use of vehicles, pedestrians and bicyclists (Marin County, 2004). For now, it is assumed that the existing Pacific Way Bridge would be abandoned following realignment of Redwood Creek and construction of the new bridge. Further consideration may be given to preserving the existing bridge as emergency flood capacity, or if the existing creek is maintained as a backwater channel. In either event, Pacific Way Bridge should be widened from approximately 15 feet to at least 28 feet to allow two-way traffic.

We understand that Marin County and NPS have preliminarily discussed four options for the bridge design: 1) a causeway, 2) a bridge, 3) a combination bridge with overflow culverts, and (4) an elevated road with a series of culverts (Vick, *pers comm.*, 2003). The County also has also requested that porous pavement be considered in the bridge design. We understand that Marin County Public Works Department will work with NPS to determine the most appropriate construction alternative for the bridge to meet project goals (Vick, *pers comm.*, 2003).

Table 5-1. Hydraulic Modeling Results for Different Bridge Scenarios

Alternative (at Year 0)	Bridge Width (ft)	Estimated Water Surface Elevation for Q-50 (feet NGVD)		
		260 ft Downstream (Section-F[1])	130 ft Upstream (Section-D[1])	660 ft Upstream (Section-B[1])
1	Existing[2]	14.7	15.9	18.0
2	No Bridge[3]	13.7	15.8	18.0
	310	13.7	15.9	18.0
	240	13.7	16.0	18.0
	190	13.7	16.2	18.0
	125	13.7	16.6	18.1

[1]See Figures A-1 and A-2 for locations of cross-sections F, D, and B.

[2]Results are for Alternative 1 (No Action) with the existing bridge at Pacific Way.

[3]Results are for Alternative 2 (Creek Restoration) assuming no constraints at Pacific Way (i.e. no raised roadway or bridge.) Provided for comparison purposed only. This hypothetical scenario would not provide any resident/visitor access to the beach.

5.3.1.6 Wetlands and Red-legged Frog Habitat

Each restoration alternative includes wetland areas that are intended to improve breeding and rearing habitat for California red-legged frog. Alternative 2 includes a proposed wetland/pond complex at the confluence of Green Gulch Creek and Redwood Creek. For Alternatives 3 and 4, the wetlands associated with the margins of the new lagoon(s) would provide a gradient of wetland habitats suitable for red-legged frog breeding and rearing. Although detailed grading plans have not yet been developed, the final design for these wetland areas should incorporate as many of the elements discussed below as possible to enhance habitat for California red-legged frog.

The proposed wetland/pond complex at the confluence of Green Gulch Creek and Redwood Creek under Alternative 2 was included in the design specifically to improve breeding and rearing habitat. The on-channel wetland/pond complex would be approximately 0.9 acres in area and vary in elevation up to +5 feet NGVD. The conceptual design of the wetland was based primarily on criteria for hydroperiod (*e.g.,* depth, duration, and frequency of inundation) and vegetation developed from the literature, local expertise, and NPS staff input.

Greater oviposition and hatching success has been correlated with wetlands that provide ample shoreline habitat and interspersion of open water and vegetation, with shallow grade and depths of 4 to 40 inches (10–100 cm) (Richter 1997). In addition, Richter (1997) suggests minimizing flow velocities to 0.07 feet/s (2 cm/sec) during the period between oviposition and hatching to minimize hydraulic shear stress impacts to attached egg masses. Hayes and Jennings (1988) found California red-legged frogs in Central Valley drainages almost exclusively (99%) at sites with some water at least 27.5 inches (70 cm) deep. Fellers (*pers. comm.*, 2003) emphasized the need for a permanent ponded area with a suggested minimum pond size of 60 feet by 160 feet, at least 6 feet deep (to maintain perennial open water where emergent vegetation could not encroach). The depth of standing water suggested by Fellers is greater than that cited by Richter (1997) or Hayes and Jennings (1988); however, the behavioral response to predators by both subspecies of red-legged frogs includes fleeing directly into water and into the deepest portion of the channel or pool (Gregory 1979, Jennings, M., *pers. comm.*, both as cited in Davidson 1993), thus, maintaining some deeper water areas may be important for adult predator avoidance.

With these elements in mind, the emergent wetland area for Alternative 2 may include one or more off-channel depressional areas to provide more permanent standing water with milder fluctuations in water level. Any permanent off-channel features would need to consider issues of fish stranding and mosquito control in the final design. Smaller fish released or entrapped in these ponds may prey upon eggs and tadpoles. Although hydraulic control structures can be used to regulate water surface levels for wetlands (similar to interim measures currently being performed), this approach is considered inconsistent with the overriding project goal of a geomorphically self-sustaining ecosystem and would likely result in rapid sedimentation.

Wetland areas presented for each alternative could maintain and/or improve suitable habitat for red-legged frogs through the inclusion of various microhabitat design features in the final design (e.g., snags, downed wood, and varied topography. Vegetated buffer areas with ample large downed woody material (i.e. logs) are recommended for red-legged frog habitat to facilitate upslope movement by amphibians following metamorphosis (Richter 1997). Fellers (*pers. comm.*, 2003) emphasized similar elements as Richter, mainly providing appropriate conditions for colonization by emergent vegetation. He also suggested the following: 1) leaving some parts of the site undisturbed during construction (e.g. moist willow thicket areas) to allow for adult refugia, 2) actively planting bulrush, cattails, and other emergent wetland species in the new habitats to ensure rapid colonization, and 3) placement of a few snags in the area for cover. In addition, variations in surface topography are desirable because they would increase the likelihood that a suitable combination of emergent vegetation and water levels would occur during the breeding and larval rearing seasons.

It is also important to consider expected salinity levels in the design and evaluation of wetlands as suitable red-legged frog habitat. Water salinity has been found to be the most significant mortality factor in the pre-hatching stage of red-legged frogs in coastal California lagoons (Jennings et al. 1992, as cited in USFWS 1996). Complete mortality occurs in eggs exposed to salinity levels greater than 4.5 parts per thousand (ppt) (Jennings and Hayes 1990, as cited in USFWS 1996), and larvae begin to die with exposure to salinity levels greater than 7.0 ppt (Jennings, *in litt.*, as cited in USFWS 1996). The USFWS (1996) also notes that drought can exacerbate salinity levels in coastal lagoons, citing examples from Pescadero Marsh Natural Preserve in San Mateo County and Santa Rosa Creek and lagoon in San Luis Obispo County. With this in mind, the salinity levels in the small and large lagoons under Alternatives 3 and 4 may significantly hinder successful frog reproduction. The area of actual wetland habitat under Alternatives 3 and 4 available for red-legged frog breeding may be limited to areas in the immediate vicinity of the freshwater inflows of Redwood and Green Gulch creeks.

6. DEVELOPMENT OF PUBLIC ACCESS OPTIONS

Different approaches were developed for providing public access to the site, in a manner that would minimize impacts to geomorphic processes and ecological function. Public access improvements include basic amenities for park visitors, such as parking, picnic areas, restrooms, access and recreational trails, and interpretive facilities. In addition to the No Action scenario, three public access "options" have been developed that are, for the most part, interchangeable with the restoration alternatives. Key issues considered in the development of the public access options include the following:

- Proximity of parking/drop-off areas to beach
- Parking demand
- Character and visibility of parking lots
- Traffic and vehicle access
- Connections among trails
- Sensitive habitat areas and buffers
- Interpretive features
- Character of landscapes

The four public access options are shown on Figures 18 through 21, and described in more detail below. Section 6.6 provides a summary of how the range of parking under each option would satisfy the current parking demand. An evaluation of these options relative to the project objectives is provided in Section 9.

6.1 OPTION A – NO ACTION

This option keeps the parking lot unchanged in its current position, close to the beach. Most visitors experience the site currently as a trip to the beach, with the parking as close as possible to the resource. There are connections to a loop trail, and the southerly Coastal Trail in the project area, but the primary experience for most visitors is the beach.

6.1.1 Visitor Parking

The 175-car parking lot is a single large area paved in gravel, without separately marked spaces and without trees. The lot is highly visible from the south Coastal Trail and from the hillside residences, but is screened from view from Highway One by riparian vegetation. The stark contrast between the bare dusty parking lot and the surrounding landscape creates the impression that the lot has been imposed on the space rather than integrated with it. The visitors would continue to reach the beach through the dunes by crossing a footbridge at the end of the lot. There is no provision for a shuttle stop.

According to the *Comprehensive Transportation Management Plan* (CTMP), parking demand on an average peak-season weekend day is 200 cars, 25 cars more than the capacity of the existing lot. This situation occurs roughly 12 days per year, such that illegal overflow parking spills over onto the shoulders of Pacific Way and Highway One. (Refer to Section 4.4.1.2 and Table 4-8 of Part I. for more information on the patterns of parking demand through the year.) This situation would continue under this option, unless others make improvements as a result of the CTMP.

6.1.2 Vehicle Access: Pacific Way

Pacific Way is the primary access road to the beach parking lot, and it would remain unchanged in this option. The road is shared with residents of Muir Beach and guests at the Pelican Inn. Its width varies from about 16 feet to 28 feet: too narrow to accommodate two-way traffic plus parallel parking, so it becomes very congested when there is illegal parking along the shoulders. When vehicles are parked along the shoulders, emergency vehicle access is compromised. The existing bridge, in particular, is too narrow for two-way traffic, causing bottlenecks with high traffic volumes.

6.1.3 Visitor Access and Experience

The trails and roads would remain as they are now. There is a popular internal loop trail around the site that includes portions of the Green Gulch Trail, the Green Gulch access road, Pacific Way, and the Levee road. The southerly Coastal Trail connects with this loop, with a link to the beach, but is discontinuous with the other regional trails, including the Diaz Ridge Trail, Redwood Creek Trail, and the northerly Coastal Trail. An informal emergency-access staging area would remain across Redwood Creek from the parking lot near the toe of the southerly Coastal Trail. The emergency access route to the staging area is along the Levee Road to the Coastal Trail. The paddock and riding ring for horses would remain southwest of the corner of Pacific Way and Highway One. In addition, the picnic area and bathrooms at the southeast end of the parking lot would remain.

Although most trails and roads have adequate habitat buffers, there is little or no buffer between the trail on the Levee Road and either the existing backwater habitat or the emergent marsh. Both of these sensitive habitats are subject to conflicts with the trail users. In addition, the abutments for the bridge between the parking lot and the beach constrict the creek at an important transitional habitat.

6.1.4 Interpretive Facilities

There is little interpretation at the site at present, but there are some interpretive themes that could be developed using the resources as they currently exist. Interpretive themes for the site could include the archeological and cultural heritage, historic landscape alterations, salmonid cycles, beach processes, and watershed relationships. The generally degraded state of the existing natural hydrologic and biotic systems, however, might limit the range of interpretive opportunities.

6.1.5 Visual Character

The overall landscape of the No Action option is in a state of transition, because sedimentation in the creek has caused the groundwater level to rise. The elevated groundwater level is causing the mostly open pastureland at the center of the project site to convert rapidly to cattail marsh. The character of this landscape is changing from a pastoral agricultural scene—grazing herds in a grassy meadow—to more of a natural-appearing wetland habitat. A visitor can see across the pasture/marsh from all sides, with the views enclosed at the edges by riparian woodlands and the surrounding hills. It is expected that the riparian forests would expand along the outer margins of the emerging wetlands and further enclose the views. Redwood Creek would still be confined to its narrow, artificial channel, above the pasture and behind the levee, hidden within the riparian forest. The visible drainage channels would continue to be the ditches crossing the pasture from Green Gulch Farm.

6.2 OPTION B – PARKING LOT AT BEACH

This option keeps all the parking close to the beach. All visitors would arrive at the beach parking lot or drop-off. People would have direct access to the beach along a trail and bridge from the parking lot. There would be easy connections to a loop trail system around the wetland restoration area and to the regional trails, but the primary experience for most visitors would be access to the beach, similar to the current experience.

6.2.1 Visitor Parking

The existing parking lot would be reconfigured to reduce impacts on the creek. The number of parking spaces that could be accommodated under this alternative ranges from 90 to 200. If the parking lot and picnic area were pulled back 90 feet but no other alternation made to the lot, the remaining fill could accommodate 90 parking spaces with a transit turnaround or 145 parking spaces without a transit turnaround. Accommodating additional cars at this location would require expanding the parking lot northward into riparian woodland/wetland. Within the area identified by the hydraulic model as suitable for potential fill, the expanded parking lot could accommodate up to 200 cars and a transit turnaround. This lot, however, would require placing fill into 1.4 acres of riparian woodland/wetland.

The new parking lot would be generally as visible to the Coastal Trail and hillside residents as is the existing lot, and would be similarly screened from Highway One. The lot itself, however, would be configured to accommodate a dense native tree cover in planting bays between the rows of parking and in planting islands separating groups of vehicles. The intended effect is to extend the native riparian woodland into the parking lot and visually knit the landscaped parking lot with its setting.

6.2.2 Vehicle Access: Pacific Way

Vehicle access would change slightly. Pacific Way from Highway One to the parking lot would be rebuilt with a uniform width (to be determined, minimum 16 feet, maximum 20 feet) to allow two travel lanes, which would also serve emergency vehicles, but without parking along the street. A new bridge or causeway over Redwood Creek would be built with greater clearance and longer spans, to avoid confining the creek and avoid future flooding, and wide enough to accommodate a pedestrian walkway (trail link). Under this option, traffic volumes on Pacific Way would be about the same as the existing conditions. Currently, on peak weekends, visitors enter the parking lot looking for parking, and then return to park along the shoulder if the lot is full. A second roadway connection to Pacific Way would be provided for the parking lot, and would serve to lessen congestion in the lot itself during peak times.

6.2.3 Visitor Access and Experience

Visitors would reach the beach through the dunes by crossing Redwood Creek on a new footbridge near the location of the existing bridge, built long enough to allow the creek channel to vary as needed. A circle for shuttle drop-offs could be included at the southwestern corner of the lot, and a new restroom building would be built next to the drop-off circle. A picnic area would be provided east of the parking lot.

The network of off-road trails would be connected into a loop. From the southerly Coastal Trail, a new trail would proceed westward to the beach, passing a new emergency-access staging area and connecting to the parking lot by the new footbridge over Redwood Creek. Another trail from the Coastal Trail would proceed eastward around the restoration area toward Green Gulch, connecting to the Green Gulch Trail. This loop trail would continue across Green Gulch Creek along the old Green Gulch Access Road parallel to, but below, Highway One, to a new path along Pacific Way. The leg of the trail along Pacific Way in this option would be located in the former creek bed, detached from the road, and would lead visitors from the parking lot to the Pelican Inn across the new expanded road bridge. This option supports future potential connection of the Diaz Ridge Trail and Redwood Creek Trail at the stable/old dairy complex, which would require that the Highway One/Pacific Way intersection be configured to accommodate a regional trail linkage. The horse paddock at Highway One and Pacific Way would remain, but the riding ring would be removed. The old levee road emergency access route would be abandoned, and replaced by the eastern leg of the new loop trail, upgraded to accommodate emergency vehicles.

Expanding the parking lot to accommodate up to 200 cars and a transit turnaround would remove up to 1.4 acres of existing riparian woodland/wetland to the north of the existing parking lot. The new lot could be configured so as to be set back from the emergent wetlands by a minimum of 100 feet and from the creek by 175 feet. These setbacks would provide buffers to the restored habitats and remove obstructions to the flood flows. Elimination of the levee road/trail would further limit human intrusions into the center of the restored habitat; public access around the restoration areas would be confined to the perimeter trails. A single penetration into the sensitive restored habitat on an elevated overlook deck is proposed near the confluence of the main stem of the creek with its tributaries upstream of the pedestrian bridge. The pedestrian bridge would be lengthened so that the abutments would be less of a constriction to the creek flows than in the No Action Option.

6.2.4 Interpretive Facilities

More opportunities for interpretation would be available under this option than in the No Action option. Interpretive themes could be expanded to include the millennia-long interaction of humans (Coast Miwoks through modern cultures) with this ecosystem as well as native habitat and ecological restoration. Interpretive features could be placed at the parking lot, at the new footbridge over Redwood Creek, and at the end of the southerly Coastal Trail. An interpretive bird-blind/overlook near the confluence of the creek and its tributaries could bring visitors through a buffer of riparian forest to see into and over the emergent wetlands.

6.2.5 Visual Character

The overall character of this landscape (Option B paired with restoration Alternative 2) leading to the restored dunes and beach would be a natural appearing wooded stream corridor, with riparian forest filling the adjacent floodplain. The existing open meadows and marsh would be changed to a more heavily wooded floodplain with a stream and tributaries moving through it. The stream would be sited in the lowest part of the valley, rather than artificially perched to one side. The new woodlands would block open views across the former meadow, except in low-lying cattail marsh areas.

6.3 OPTION C – PARKING LOT AT BEACH & ALDER GROVE

Option C retains a parking lot close to the beach, but also adds a small second parking lot at the Alder Grove along Highway One to the northwest of the Pelican Inn. Most visitors would arrive at the beach parking lot or drop-off and proceed directly to the beach as in Options B and No Action. However, some visitors would arrive at the remote parking lot and walk along the stream corridor and restored wetlands in order to get to the beach. In this option, visitors are offered an expanded ecological experience along the half-mile trail from the remote parking lot to the beach, in which the upstream context for the beach is encountered as a routine part of the trip. The visitor would also have a choice of a somewhat longer (0.7-mile) but more varied trail to the beach.

6.3.1 Visitor Parking

Under this option, parking would be accommodated in two lots, one at the beach and one approximately one-half mile from the beach along Highway One. As in Option B (above), the existing parking lot would be reconfigured to reduce impacts on the creek. The number of parking spaces that could be accommodated at the beach site would range from 90 to a maximum of 150. Additional parking would be accommodated at a separate 50-car lot located in the Alder Grove (north of the Pelican Inn along Highway One). Accommodating 150 cars and a transit turnaround at the beach lot would require placing fill in 0.9 acres of riparian woodland/wetland. The 50-car Alder Grove lot would require an additional 0.7 acres of fill into riparian woodland/wetland. As with Option B, the lots would minimize hydraulic effects on the creek and would be set back a minimum of 100 feet from the emergent wetlands.

As with Option B, visitors would reach the beach from the beach parking lot through the dunes by crossing Redwood Creek on a new footbridge near the location of the existing bridge, built long enough to allow the creek channel to vary as needed. A new restroom building would be built between the lot and the footbridge. A circle for shuttle drop-offs could be included at the southwestern corner of the parking lot. A picnic area would be provided east of the parking lot. The remote lot, built to hold 50 cars, would be located at least 160 feet from the nearest residential property line.

The parking lot at the beach would be generally visible to the Coastal Trail and hillside residents (as are both the existing lot and the lot included in Option B) and would be similarly screened from Highway One. The remote lot at the Alder Grove would be set back from Highway One by approximately 25 feet and screened by vegetation, but would be generally visible through the trees. Each of the lots would have planting bays between the parking rows and within each row, to surround the vehicles with a dense cover of native trees.

6.3.2 Vehicle Access

Vehicle access to the beach parking lot would be similar to Option B but with an important difference. A new access drive for the parking lot would be developed approximately 400 feet upstream of the existing access point, with a sign and gate installed just beyond the new drive along Pacific Way to control public access into the residential district. The residents (and the shuttle bus, if one is added in the future) could use the gate. Pacific Way and a new bridge or causeway over Redwood Creek would be similar to those mentioned above in Section 6.2.2. On peak weekends when the parking lot would fill up, a sign would be required at the Highway One/Pacific Way intersection to direct vehicles to the remote lot. If private vehicles use the drop-off when the parking lot is full and then return to the remote lot for parking, the traffic on Pacific Way might remain the same at peak hours or might even increase. If shuttles use Pacific Way, they would add to the congestion.

The remote 50-car lot at the Alder Grove would require a new entrance/exit along Highway One. New left-turn maneuvers and entries onto Highway One would increase the congestion along this stretch of the highway, especially during peak times.

6.3.3 Visitor Access and Experience

The network of trails on the project site would be reconfigured into a loop, as in Option B. The difference between the trail system in this option and Option B is the alignment of the segment of the loop along Pacific Way. In this option, the Pacific Way leg of the trail would be adjacent to the road, with a protective separation from the driving lane, rather than in the former creekbed. The potential regional trail connections, the emergency access route, and the horse-paddock configuration would remain the same as in Option B.

As with Option B, trails would be routed around the outside perimeter of the restoration area, and eliminating the levee road would limit human intrusions into the center of the restored habitat. A single penetration into the edge of the restored wetland habitat on an elevated overlook deck is proposed at the small eastern lagoon in the vicinity of the Green Gulch Access Road. As with Option B, the new pedestrian bridge between the parking lot and the dunes would be lengthened so that the abutments would not constrict the creek flow as in the No Action Option. The trail from the remote Alder Grove lot to Pacific Way would pass through the riparian zone, but would be held back from the top of the creek bank by 100 feet.

6.3.4 Interpretive Facilities

The interpretive opportunities with this option would be generally the same as with Option B. However, there would be more variety in the habitat types that could be seen, including a mix of open water and riparian systems. In addition, the walk from the Alder Grove lot to Pacific Way would offer an opportunity for interpretation of the riparian area from within the forest, unlike the other perimeter trails. Interpretive displays are proposed at the Alder Grove lot, at the interpretive blind/overlook, at the southerly Coastal Trail connection, at the pedestrian bridge, and near the dune restoration area at the beach lot.

6.3.5 Visual Character

The character of this landscape (Option C paired with restoration Alternative 3) would be a natural stream corridor with dense riparian woodlands, leading to a small open coastal lagoon upstream of the dunes and beach. It would have more open water and appear to have more ecological complexity than Alternative 2, but it would seem equally well fitted to the setting as a dynamic natural system. For those visitors who park in the remote Alder Grove lot and choose the longer route to the beach, the landscape character would change sequentially from the closed riparian woodlands to open water and marsh to the dunes and beach. Seasonal changes in the water levels would be more evident in this option than Alternative 2, lending an ephemeral and visibly dynamic quality to this alternative. Views from Highway One would be partially screened by trees, with some open vistas across open water.

6.4 OPTION D – PARKING LOT AT ALDER GROVE

Option D would remove the parking lot near the beach, allowing only a visitor drop-off place, a transit turnaround, and 14 disabled parking spaces. At times of low parking demand, some of the disabled parking spaces might be made available for non-disabled use. A new 118-vehicle lot at the Alder Grove would be developed, the largest lot compatible with the floodway in this location. Other than those dropped off by shuttle, most of the visitors (as compared to only one-quarter of them, in Option C), would arrive at the remote lot and walk one-half mile to the beach along the new creekside trail with its attendant ecological experience.

6.4.1 Visitor Parking

A total of 132 vehicles could be accommodated in the two parking lots, which is less than both the peak-season weekend demand of 200 cars and the shoulder-season weekend demand of 160 cars but slightly more than the off-peak season weekend demand of 120 cars. Refer to Section 6.6 for the summary comparison of supply and demand. Until and unless transit services or additional parking is provided in the future through the CTMP, all variations of this option would reduce accessibility of the beach to park visitors.

The Alder Grove parking lot would be configured similar to the Alder Grove lot in Option C, although more than double the size. It would be set back from the top of the creek bank by a minimum of 175 feet, from the westerly adjacent property line by a minimum of 135 feet, and from the northerly property line by a minimum of 75 feet. It could have planting bays between the rows of cars and planting islands separating groups of cars within each row. The lot would be generally visible from Highway One through a 25-foot screen of trees. The distance and tree cover between the residential properties and the adjacent residential lots would provide an adequate screen. The beach drop-off and disabled parking would be a simple circular form of approximately 38,000 square feet in area (or 45 percent of the area of the existing parking lot). This is significantly smaller than the parking lot in the No Action option, as well as Options B and C, with less visual impact to the Coastal Trail and the hillside residents. A large island of planting in this parking lot would further help to reduce visual impact.

The new parking lot at the Alder Grove would require the removal of 1.3 acres of riparian woodland. The shuttle drop-off and disabled parking at the beach would be within the footprint of the existing parking and would have little to no impact on the existing riparian woodland to the north of the existing lot. The new Alder Grove lot would be set back at least 180 feet from the creek and, based on the hydraulic model, is not expected to increase water surface elevations during floods up to the 50-year flood (4,140 cfs).

6.4.2 Vehicle Access

The new lot in the Alder Grove would require a new entrance/exit connection to Highway One. The new left-turn maneuvers from Highway One, and entries back onto to it, would increase congestion along this stretch of highway during peak times. The effects would be greater under this option than under Option C because the lot would be larger. Vehicular access to the beach along Pacific Way would be the same as in Option C, with comparable improvements except at the drop-off. Traffic congestion along Pacific Way to the shuttle drop-off would diminish under this option, although some visitors might use the drop-off before parking their cars at the remote lot. The extent to which the drop-off is used for daily visitors would affect the traffic levels on Pacific Way, similar to the situation described in Section 6.3.2.

6.4.3 Visitor Access and Experience

As in Option C, the Alder Grove lot would lie roughly one-half mile from the beach. This option would require most visitors to walk this distance. A choice would be available for beach users to take a longer route—approximately 0.7 miles—around the restored wetlands through the dunes to the beach.

From the shuttle drop-off, visitors could reach the beach directly on a new boardwalk over Redwood Creek. Such a boardwalk existed in the early 1900s, when there was more development in the vicinity of the current parking lot. It would be durable enough to resist the storm-surges sure to hit it each winter. New restroom buildings would be built near the drop-off and at the Alder Grove lot. A picnic area would be provided east of the drop-off and the disabled spaces, and would lie within the 50-year floodplain.

The network of trails on the project site would be connected into a loop, as in Options B and C, but the loop would include a 700-foot stretch on the beach itself without any paved improvement. There would be no secondary creek crossing other than the boardwalk between the beach and the drop-off. The remaining trails would be the same as Option C, with the exception of a boardwalk cut-off across Green Gulch Creek in the vicinity of Field 7 of Green Gulch Farms. This boardwalk would include an interpretive blind/overlook for viewing the big lagoon. Potential regional trail connections, the emergency access route, and the horse paddock configuration would remain the same as Option C. The trail connecting the new lot to Pacific Way would be set back from the creek by approximately 100 feet, as in Option C. The perimeter trail system would be the same as Option C, and the levee trail would be eliminated thus limiting human interventions to the perimeter of the restored habitat. The single penetration into the habitat zone for interpretive purposes would be the elevated boardwalk that would cross Green Gulch Creek and overlook the northeasterly end of the restored lagoon.

6.4.4 Interpretive Facilities

Interpretive opportunities would be the same as with Option C. However, the larger lagoon and open water habitat would enable a different palette of potential interpretive themes for the restored natural system. Interpretive facilities could be provided at the remote parking lot, at the Green Gulch Creek crossing, at the intersection of the southerly Coastal Trail with the loop trail, and at the shuttle drop-off.

6.4.5 Visual Character

The character of this landscape (Option D paired with Alternative 4) would be that of a natural coastal lagoon with a large expanse of open water, associated wetlands, and riparian forest. The visual effect would be similar to the condition in 1853, before intensive farming and other land use activities in the watershed transformed the lagoon into a filled meadow. Seasonal fluctuations in water level would be an important feature that would be highly visible at this place. Over the decades, visitors would be able to watch as the lagoon gradually filled in with sediment, transforming into a smaller lagoon and eventually to a channel and floodplain. Most visitors would have to walk the distance between the Alder Grove and the beach, and they would experience a sequential variety of landscapes on the journey. Dramatic views of the lagoon from Highway One would be only partly screened by a thin veneer of trees at the margins of the wetlands when first constructed, then gradually closed as the lagoon fills in and the trees encroach.

6.5 COMPATIBILITY WITH RESTORATION ALTERNATIVES

Although the above descriptions associate each public-access option with one restoration alternative, other combinations are possible. In each case, the ecological requirements dictate which parking lot layout is compatible with which restoration alternative.

Option A would work only with Alternative 1 (No Action). The existing beach parking lot encroaches on the creek corridor and affects hydraulic processes. All restoration alternatives require alterations to the existing lot to remove hydraulic constraints.

Options B and C would work with Alternatives 2 or 3 (Creek Restoration or Creek and Small Lagoon Restoration). The reconfigured parking lots at the beach are set back sufficiently from the creek and lagoon wetlands and adequately buffered to allow the natural processes to develop unimpeded. These options would not be compatible with Alternative 4 (Large Lagoon) in its current configuration, since the large lagoon would take up most of the land proposed for the beach parking lot. The lagoon would have to be reconfigured to accommodate more parking.

Option D would work with any of the three restoration alternatives (2, 3, or 4), since the primary parking lot would be moved out of the beach area.

The compatibility of the public-access options with the restoration alternatives is summarized below.

Table 6-1. Compatibility of Public Access Options with Restoration Alternatives

Public Access Options		Preliminary Conceptual Alternatives			
		Alternative 1	**Alternative 2**	**Alternative 3**	**Alternative 4**
		No Action (Existing Conditions)	**Creek Restoration**	**Creek & Small Lagoon Restoration**	**Large Lagoon Restoration**
A	**No Action**	**YES**	NO	NO	NO
B	**Parking Lot at Beach**	NO	**YES**	**YES**	NO*
C	**Parking Lot at Beach & Alder Grove**	NO	**YES**	**YES**	NO*
D	**Parking Lot at Alder Grove**	NO	**YES**	**YES**	**YES**

* = unless the large lagoon were reduced in size to accommodate a parking lot at the beach.

6.6 SUMMARY OF PARKING SUPPLY AND DEMAND

In the above sections, the host of numbers mentioned—the range of parking spaces under each option and whether they meet or exceed the existing demand parking demand—may be difficult to evaluate. The following tables summarize how the parking spaces possible under each option compare to the existing and future parking demand at various times of the year. The values for existing parking demand presented in Table 6-2 are taken from Table 4-8 of Part I. The numbers for predicted future parking demand in Table 6-3 are taken from Robert Peccia & Associates, preliminary data file, "CTMP Exist & Fture [*sic*] Dmd Parking IV (8-29-03).xls".

Table 6-2. Summary of Parking Supply and Current Demand

Range of Parking Provided by Public Access Option		% of Current Demand					
		Peak Season		Shoulder Season		Off-peak Season	
		Weekend (200 cars)	Weekday (160 cars)	Weekend (160 cars)	Weekday (115 cars)	Weekend (120 cars)	Weekday (30 cars)
A	No Action (175 spaces)	90%	**110%**	**110%**	**150%**	**145%**	**580%**
B	Beach Parking Lot (90-200 spaces)	45%-**100%**	55%-**125%**	55%-**125%**	80%-**175%**	75%-**165%**	**300%-670%**
C	Beach & Grove Lot (140-200 spaces)	70%-**100%**	90%-**125%**	90%-**125%**	**120%-175%**	**115%-165%**	**470%-670%**
D	Alder Grove Lot (64-132 spaces)	30%-65%	40%-80%	40%-80%	55%-**115%**	55%-**110%**	**210%-440%**

Percentages in **bold** indicate where supply satisfies or exceeds demand.

Table 6-3. Summary of Parking Supply and Predicted Future (2023) Demand

Range of Parking Provided by Public Access Option		% of Predicted Future (2023) Demand					
		Peak Season		Shoulder Season		Off-peak Season	
		Weekend (260 cars)	Weekday (210 cars)	Weekend (200 cars)	Weekday (145 cars)	Weekend (175 cars)	Weekday (50 cars)
A	**No Action (175 spaces)**	70%	85%	90%	**120%**	**100%**	**350%**
B	**Parking Lot at Beach (90-200 spaces)**	35%-75%	45%-90%	45%-**100%**	60%-**145%**	50%-**115%**	**180%-400%**
C	**Parking Lot at Beach & Alder Grove (140-200 spaces)**	55%-75%	70%-90%	70%-**100%**	95%-**140%**	80%-**115%**	**280%-400%**
D	**Parking Lot at Alder Grove (64-132 spaces)**	25%-50%	30%-65%	30%-65%	45%-90%	35%-75%	**130%-265%**

Percentages in **bold** indicate where supply satisfies or exceeds demand.

7. EVALUATION OF ECOLOGICAL RESTORATION ALTERNATIVES

7.1 ASSESSMENT METHODS

Each restoration alternative, including the No Action Alternative, was evaluated to describe its expected geomorphic evolution and ecological function within the 50-year planning horizon. For this evaluation, we looked at three snapshots along the evolutionary trajectory, Years 0, 5 and 50. Physical processes – hydrology, hydraulics, sediment transport – were evaluated at Year 0, immediately following project implementation. Ecological function was then described for Year 5, allowing time for vegetation to respond to changes in physical processes at the site. Near-term conditions for each alternative are shown in plan and section in Figures 6 through 13. These depictions show roughly Year 0 topography with Year 5 habitat types. Site topography is not expected to change significantly within the first five years between Years 0 and 5, unless a large disturbance event occurs (flood, fire, etc.).

Based on our understanding of how the site would evolve within the planning horizon, we then predicted the expected landscape at Year 50 for each alternative (Figures 23 to 25), and described the future physical and ecological function. The geomorphic analysis used for predicting site evolution (described in detail in Section 7.1.1) relies on a number of simplifying assumptions and is subject to considerable uncertainties. For example, we assumed that the average annual sediment delivery provide by Stillwater (2003) would be representative of long-term conditions, but recognize that actual sediment delivery will be episodic. Furthermore, the future watershed sediment delivery provided by Stillwater (2003) is based on a number of uncertain assumptions, such as future watershed recovery and future meteorological conditions.

Specific methods used to assess the physical and ecological function of each alternative are described in the following sections.

7.1.1 <u>Geomorphic Evolution</u>

The geomorphic evolution of the project site under each alternative from the Year 0 site template to Year 50 was predicted based on projected future sediment deposition patterns. Predicting geomorphic changes over a 50-year time scale requires a number of simplifying assumptions and is subject to uncertainties, especially in a system like Redwood Creek where there is a short record of actual sediment transport measurements.

Stillwater (2003) predicted the future average annual sediment delivery to the project site based on a sediment budget analysis. Stillwater (2003) did not provide an error estimate for this future sediment delivery rate. Given the uncertainties in the present rate of delivery and the uncertainty of future watershed recovery, the sediment trapping potential on the floodplain upstream, and future meteorological conditions a reasonable estimate of error is likely in the range of ±25-50%. Given the uncertainties involved and the conceptual level alternative development, we believe that using long-term average site trapping rates and delivery rates is the most appropriate method for predicting the 50-year geomorphic evolution of the project site.

Under each alternative, we used the average annual sediment volumes, an estimate of sediment trapping potential and knowledge of flood pathways and deposition patterns to project future topographic changes. The expected flood pathways were based on field observations as well as hydraulic modeling results. Table 7-1 summarizes the estimated sediment trapping potential of each alternative and the net sediment deposition expected by Year 50.

We assumed a grain size of 2 mm to be the break between bedload and suspended sediment. Stillwater (2003) performed pebble counts of the Redwood Creek bed and found an average D_{50} of 18.5 mm near the project site (stations 9 and 10). No estimate of suspended sediment size was provided, so we assumed suspended sediment to be 25% sand and 75% silt and clay as a long-term average (averaging over a range of flow conditions) based on Willis and Griggs' (2003) inventory of coastal California rivers. We also assumed that the average annual sediment delivery would be representative of long-term conditions but recognize that actual sediment delivery will be episodic, depositing large amounts of sediment during periodic major storm events with little sediment delivery in intervening years.

Our trapping rate for Alternative 1, 80% bedload and 25% suspended sediment, was based on measured channel deposition between Pacific Way bridge and the parking lot from 1992 – 2001 and 2001 – 2002 (see Section 4.2.3 in Volume 1). Hydraulic modeling of Alternative 2 showed improved channel conveyance and a consistent bed shear profile, indicative of improvements in sediment transport capacity. Based on these modeling results and the grain size assumptions noted above, we estimated a trapping rate for Alternative 2 of 30% bedload and 15% suspended sediment, with larger bedload and suspended sediment fractions being trapped in the channel and the smaller suspended fractions being deposited on the floodplain. Alternative 3 was not modeled explicitly, but it has an identical channel profile and geometry as Alternative 2. However, recognizing that the small lagoons would tend to act as sediment traps with low velocity flows, we estimated that Alternative 3 would likely trap about 50% of the bedload and 30% of the suspended sediment.

We treated the Large Lagoon in Alternative 4 as a small reservoir, since high velocity flows from the creek channel would quickly decelerate upon entering the lagoon and deposit the sediment in transport. Reservoirs typically trap 100% of bedload. To estimate the lagoon's suspended sediment trapping potential, we used Brune's (1953) empirical method, which relates the lagoon's capacity to the annual inflow volume from Redwood Creek.

The estimated 50-year net deposition volumes provided in Table 7-1 are more sensitive to the assumed trapping rate for suspended sediment. For example, a change of ±10% in the bedload trapping rate would result in a volumetric change of ±2,000 cubic yards over 50 years, while a change of ±10% in the suspended sediment trapping rate would result in a change of ±12,000 cubic yards over 50 years.

Deposition patterns and volumes were used to forecast topographic conditions at Year 50. Plan views (Figures 23 through 25) and channel profiles (Figures 15 and 16) were developed for each alternative to represent Year 50 conditions. For example, the Large Lagoon is anticipated to trap a significant portion of sediment delivery. By Year 50, over 75,000 cubic yards of sediment is predicted to have been deposited in the lagoon in the form of a delta prograding from the mouth of Redwood Creek into the lagoon, creating a sheltered back water area on either side of delta (Figure 25). A detailed description of the geomorphic evolution of each alternative is provided in Section 7.2.

Table 7-1. Estimated Sediment Deposition Volumes for Restoration Alternatives

Restoration Alternative	Assumed Bedload Trapping (%)	Annual Bedload Delivery(1) (yd^3/yr)	Assumed Suspended Sediment Trapping (%)	Annual Suspended Sediment Delivery(1) (yd^3/yr)	Estimated 50-Year Total Deposition (yd^3)
1	80	375	25	2,300	43,750
2	30	375	15	2,300	22,875
3	50	375	30	2,300	43,875
4	100	375	50	2,300	76,250

(1) Source: Stillwater Sciences (2003)

7.1.2 Hydraulic Modeling

Flooding potential of the alternatives was evaluated using a combination of hydraulic modeling and geomorphic analysis. A one-dimensional hydraulic model was developed in MIKE 11 for Alternatives 1, 2, and 4 at Year 0 to estimate flood elevations (see Appendix A for detailed discussion of hydraulic modeling methods). Figures A-1 to A-3 in Appendix A show the location of cross sections and flow paths inputted into the model for the alternatives. Cross sections for existing conditions were derived from the ground surveys of the creek channel performed in April 2003 (by Environmental Data Solutions) and topographic data from aerial photogrammety dated January 2003 (by Towill, Inc). Cross sections for existing conditions were then modified as needed to represent Year 0 design grades for Alternatives 2 and 4 (as shown in Figures 8 and 12). To make all hydraulic results directly comparable to No Action, the stationing of the cross-sections was based on the length of the existing channel profile as measured by EDS in April 2003. Table A-1 provides the stationing for the cross sections shown on Figures A-1 to A-3.

Alternatives 1, 2, and 4 were tested at Year 0 under Q5 and Q50 conditions, 1,600 cfs and 4,140 cfs respectively. Hydrologic inputs for the modeling were based on flow frequency curves developed for

Redwood Creek for the Banducci site, located just upstream of the project site (PWA 2000). Alternative 3 was not explicitly modeled since it has the same channel profile as Alternative 2 but with greater floodplain storage and could be expected to result in water surface elevations between Alternative 2 and 4 during the large flow events modeled in the hydraulic analysis.

Site conditions at Year 50 were then modeled for Q5 and Q50 to assess future water levels and sediment transport. Hydraulic models simulating Year 50 conditions were developed by updating cross sections for the corresponding Year 0 model with future topography based on the Year 50 plan views and profiles. Hydraulic modeling results are described by alternative in Section 7.2.

7.1.3 Hydrology

A water balance analysis was performed for each alternative to assess changes in the water budget due to vegetation changes under each alternative and to evaluate the impact of upstream diversions. The water budgets balance monthly water inputs from Redwood Creek against monthly water losses from evapotranspiration and upstream diversions at the Muir Beach Community Services District (MBCSD) well about 2.5 miles upstream of the project site (see Sections 4.2.2.2 and 4.2.2.3 in Volume I for more discussion). Based on limited data at present, water inputs from Green Gulch Creek were not considered. Inputs from Redwood Creek were based on the longest continuous record of flows on Redwood Creek at Pacific Way Bridge, March 1992 to September 1993. This period includes the 10 to 20-year drought that occurred in the summer of 1992, as well as the relatively wet 1993 season. An unimpaired flow on Redwood Creek was estimated for the same period based on the maximum permitted water diversion rates at MBCSD well (SWRCB 2001). Evaporation losses from open water were estimated from monthly average pan evaporation totals from Lagunitas Reservoir (about 28 inches/year). Transpiration losses were computed assuming that all wetland and riparian plants consume about 35 inches/year (PWA et al., 1994). The combined evapotranspiration losses were assumed to be drawn directly from Redwood Creek and the restored lagoons. When water losses exceeded water inputs from Redwood Creek, the resulting drop in the water surface was estimated based on the area of open water for each alternative. Tables B-1 to B-4 in Appendix B summarize the water balance calculations.

Groundwater elevations and expected water depths under the alternatives were projected for Year 0 and 50 (Table 7-2). Under No Action, groundwater elevations are anticipated to be the same as measured in 2003, ranging from +8 ft NGVD in the winter to +4 ft NGVD in the summer in Green Gulch pasture (Figure 22). Under Alternatives 2 to 4, groundwater elevations are expected to decrease by about approximately 1 foot, due to the lowering of the channel thalweg from +4 to +3 NGVD downstream of the footbridge. The maximum lagoon water depths at Year 0 and Year 50 were estimated based on the maximum depth of the lagoon bed and the assumption that water depths would be controlled principally by groundwater elevations during the summer season.

Table 7-2. Approximate Groundwater Elevations and Water Depths for Alternatives 2 to 4

Month	Avg. Creek Inflow (cfs)	Avg. Tidal Range (feet)	Avg. Groundwater Levels at Year 0 (feet NGVD)[A]	Max. Small & Large Lagoon Depths at Year 0 (feet)[B]	Max. Small Lagoon Depth at Year 50 (feet)[C]	Max. Large Lagoon Depth at Year 50 (feet)[C]
Oct	0.1	0[D]	3.0	4.0	1.0	3.0
Nov	0.0	0[D]	4.5	5.5	2.5	4.5
Dec	15.4	1.5[E]	6.0	7.0	4.0	6.0
Jan	64.5	1.5[E]	6.0	7.0	4.0	6.0
Feb	37.2	1.5[E]	7.0	8.0	5.0	7.0
Mar	13.1	1.5[E]	7.0	8.0	5.0	7.0
Apr	8.5	1[F]	7.0	8.0	5.0	7.0
May	2.4	1[F]	6.0	7.0	4.0	6.0
June	3.7	0.5[F]	6.0	7.0	4.0	6.0
July	0.6	0[D]	5.0	6.0	3.0	5.0
Aug	0.4	0[D]	4.0	5.0	2.0	4.0
Sept	0.1	0[D]	3.0	4.0	1.0	3.0

Notes:

[A] Water levels based on groundwater data collected at Green Gulch pasture in 2003. In Year 50, groundwater elevations are expected to be about 0.7 ft higher due to sea level rise.

[B] Based on maximum water depth of -1 ft NGVD for large and small lagoons.

[C] Based on maximum lagoon depth of +1 ft NGVD for large lagoon, +3 ft NGVD for small lagoon, and assuming a 0.7 ft increase in sea level.

[D] No tidal inflow, but infrequent overwash during spring tides may result in pulses of salt water and create zones of brackish water.

[E] Tidal signal, but low tides muted to about +1 NGVD. Occasional overwash results in pulses of salt water but quickly flushed out by high winter flows.

[F] Small tidal inflow on high tides, but low tides muted to about +2-3 NGVD. Occasional overwash results in pulses of salt water create zones of brackish water.

7.1.4 Ecological Function and Evolution

The lower portions of Redwood Creek and the Big Lagoon project area provide a wide array of ecological functions. Natural watershed inputs (e.g., water, sediment, nutrients) and anthropogenic alterations to these inputs influence important physical processes (e.g., sediment transport, channel migration, stream heating) operating in the project vicinity and throughout the watershed. These processes determine the physical and chemical attributes (e.g., hydroperiod, bed substrate composition, nutrient availability) that affect habitat structure and connectivity in the stream-riparian-floodplain system of Redwood Creek.

Species abundance, distribution, and food web structure are directly affected by habitat attributes and dynamic processes that influence the persistence of these attributes. Attempts to restore river-riparian-floodplain systems will generate processes and feedback loops that will have short-term (days-months) and long-term (years-decades) effects on aquatic, riparian, and upland terrestrial ecosystems. For instance, the species composition and age-class-structure of riparian vegetation are affected by inundation regimes and sediment deposition patterns. In the short-term, reconfiguring the channel and its floodplain would alter both spatial patterns of sediment deposition and texture as well as the depth, timing, and duration of inundation. These changes would in turn affect survival, recruitment, and hence spatial and taxonomic structure of riparian vegetation and aquatic plants, and the microbial films (periphyton or aufwuchs) associated with their submerged surfaces that can influence nutrient cycling and food web structure. Changes in larger, rooted vegetation would also generate longer-term feedback in spatial patterns of sediment deposition and texture, both of which would reconfigure habitat structure and alter the food production base for invertebrates, fish, amphibians, reptiles, mammals, and birds. The formation of wetland and riparian plant communities with diverse species and age structure depends in turn upon the future disturbance regime related to annual hydroperiod, storm flood frequency, the potential for sediment deposition, frequency and intensity of fire, as well as more frequent salt water intrusion events from storm over-wash of the lower portions of the site. Aquatic and terrestrial species depend upon the recruitment of various wood decay elements (e.g., snags, down wood, litter, dead parts of live trees, hollow living trees, natural tree cavities, bark crevices, and live remnant or legacy trees).

Using the analyses described above, the resulting predictions in surface topography and surface water and groundwater variations were used to evaluate ecosystem functions related to water quality, vegetation and habitat types, and focal species under each alternative at Year 5 and Year 50 following construction.

7.1.4.1 Water Quality

Because beneficial water uses of Redwood Creek depend on unimpaired water quality from the surrounding watershed, differences in the project alternatives were assessed from the physical factors each alternative presented that affect water quality regulation. For example, riparian and wetland soil and plant assemblages help trap sediments and nutrients, sequestering some while transforming and gradually releasing others into the creek and coastal receiving waters. The primary factors evaluated include shade, water depths and volumes, and the effects of wind and wave fetch distances on mixing. Each alternative was evaluated by examining the potential differences among alternatives in the regulation of water quality through mixing and atmospheric exchanges affecting nutrient retention and cycling.

7.1.4.2 Vegetation/Habitat Types

Development of diverse vegetation and habitat types depends, in part, upon water relations and disturbance regimes. Areas of various habitat types expected to develop by Year 5 and Year 50 were determined largely based on ground surface elevations projected using the geomorphic analysis described above. Four main habitat types (in addition to open water) were assumed likely to develop on the site, given existing biological conditions (as described in detail in Section 4.3, Part I) and expected future physical (hydrogeomorphic) conditions: wetland, mature riparian (e.g., existing riparian forest and scrub), new (young or early successional) riparian, and dune scrub. Based on existing vegetation and topography, combined with available information on surface and groundwater levels, the following elevational break points were used to predict the distribution of the basic habitat types (open water, wetland, riparian) on the site under each alternative:

- +5 feet NGVD = riparian
- +1 to 5 feet NGVD = emergent wetland
- < 1 foot NGVD = open water

Open water habitat includes Redwood Creek and its tributaries, backwater channels, the tidal lagoon and all open water areas of the lagoon(s). The break point between open water and emergent wetland (+1 foot NGVD) is based on the lower elevation where emergent wetland vegetation is expected to colonize. Cattails (*Typha* spp.) tend not to colonize open water areas with at least 3 to 4 feet of standing water (Weller 1994; Steenis et al. 1958, as cited in Motivans and Apfelbaum 1987; Grace and Wetzel 1981, as cited in Motivans and Apfelbaum 1987). As described in Section 7.1.3, the average lagoon water surface is initially expected to vary from approximately to +4 feet NGVD late in the water year to +8 feet NGVD in spring. It is expected that portions of the lagoon at elevation +1 foot NGVD or lower would have at least 3 feet of standing water most of the year, and would not be colonized by emergent wetland vegetation.

The acreages of the four main terrestrial habitat types under each of the alternatives, with projections at Year 5 and Year 50, are summarized in Table 7-3.

Table 7-3. Projected Acreage of Habitat Types for Each Alternative at Year 5 and Year 50

Habitat Types	**Alternatives at Year 5 (acres)**				**Alternatives at Year 50 (acres)**			
(acres)	**1***	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Open Water	2.4	2.7	6.2	9.9	2.4	2.7	2.6	7.6
Emergent Wetland	14.9	3.7	5.5	6.8	14.9	2.2	7.3	5.6
New Riparian	0.0	10.8	5.4	3.4	0.0	0.0	0.0	0.0
Mature Riparian	13.2	11.9	12.0	9.6	13.2	21.9	17.1	15.4
Dune Scrub	0.1	0.1	0.1	0.1	0.1	2.6	2.6	2.6

* Acreage values presented for Alternative 1 are for current conditions (Year 0), which are not expected to change substantially (e.g., by 1–2 acres) within the first five years under the No Action Alternative.

For each alternative at Year 5, the acreage for emergent wetland includes the approximately 2.8-acre brackish marsh located between the existing parking lot and the tidal lagoon. Under each restoration alternative except No Action, some of this wetland is expected to evolve to dune scrub by Year 50. For Alternatives 2 through 4, the acreage for emergent wetland at Year 50 includes 1.7 acres for this smaller brackish marsh area.

The acreages presented for mature riparian do not include loss of existing riparian woodland due to parking lot expansion and associated trails. The reduction of acreage loss would depend on which public access option is selected and the size of the lot (number of spaces provided). Maximum estimated losses for each parking lot option are as follows:

- Option B - Beach parking lot (200 spaces max) = 1.4 acres
- Option C - Two parking lots (200 spaces max) = 0.9 acres (at beach) & 0.7 acres (at alder grove)
- Option D - Alder Grove parking lot (132 spaces max) = 1.3 acres

7.1.4.3 Habitat Diversity and Suitability for Focal Species

The physical factors above provide structuring influences on the establishment and maintenance of habitat quantity and quality, as well as connectivity of habitats within and outside the project area. Habitat diversity and suitability for selected focal species of amphibians and fish, as well as overall suitability for birds, were evaluated using the project objectives and indicators summarized in Table 3-1. This evaluation was based on available physical model data (presented in Figures 6 to 16 and 23 to 25) indicating (1) channel-floodplain connectivity during high flows, (2) the amounts and general locations of open-water and adjacent floodplain habitat under each alternative, (3) conceptual cross-sections and profiles under each alternative, and (4) best professional judgment regarding flow-related limitations on fish movement and the establishment of important habitat features such as instream woody debris. Thus, the analysis of alternatives was based on a relative comparison among alternatives, not a criteria-based comparison (i.e., there were no specific habitat or passage criteria used).

Ecological function and habitat suitability for fish was evaluated in terms of rearing and migration for coho salmon and steelhead — the two focal fish species. The evaluation of rearing was based primarily on the relative amount of open water habitat under each alternative (acreages provided in Table 7-3) and the expected presence of key features such as habitat type and complexity, cover, water quality, and food availability. Winter rearing habitat was evaluated in terms of the amount of low-velocity, off channel habitat, such as backwaters, side channels, and floodplains, expected under each alternative. Other habitat elements that provide flow refugia for winter rearing, such as LWD and large substrates, were also considered in the evaluation of winter rearing habitat suitability.

Suitability for salmonid migration was evaluated based on expected stream flow, water depth, and habitat connectivity during periods of peak adult migration and juvenile emigration. The availability of pools for adult holding was also considered.

Suitability for California red-legged frog breeding was evaluated based on expected distribution and abundance of wetlands with suitable emergent vegetation, seasonal patterns of water depth, and potential presence of predatory fish. See Section 5.3.1.6 for more details. General suitability for maintaining or enhancing bird diversity was assessed based on general habitat diversity and suitability for riparian/wetland associated birds was evaluated based on projected conditions of the riparian corridor (e.g., amount of riparian and wetland habitats, riparian corridor width (including wetlands) under each alternative).

7.2 EVALUATION OF GEOMORPHIC AND ECOLOGICAL EVOLUTION

Using the methods described above, the geomorphic and hydrologic processes operating under each alternative were used to predict the ecological function within a 50-year planning horizon.

7.2.1 Alternative 1 – No Action

Under the No Action Alternative, the site would continue to be shaped by the existing physical processes, requiring ongoing maintenance by NPS and Marin County to address flooding of Pacific Way. The No Action Alternative is depicted at Year 0 (existing conditions) in Figures 6 and 7. The future conceptual model (Figure 5) describes anticipated conditions if maintenance activities described in Section 5.2.1 were not implemented or become impractical. Because we assume that maintenance activities will maintain the current hydrologic regime, the site morphology and habitat types are not expected to change significantly by Year 50.

7.2.1.1 Geomorphic Evolution

Without active channel maintenance, the lower reaches of Redwood Creek would continue to lose capacity from deposition upstream and downstream of Pacific Way Bridge. Figure 4 depicts the principal physical processes that are expected to shape the morphology of the project site under No Action. As the channel fills, overbank flows are likely to occur more frequently during high flow events. A new channel will eventually form along the low point of the valley between the Highway One and Pacific Way bridges, flowing down the center of Green Gulch pasture and reconnecting to the backwater channel at the southern end of the pasture. Until a dominant channel evolves, the new channel is expected to be composed of several distributary branches. Over this evolutionary period, a main channel may not be well defined, potentially preventing upstream migration of adult anadromous fish. Diffuse flow pathways may lead to higher groundwater elevations in Green Gulch pasture, and increased wetland vegetation (e.g., cattails) and back beach elevations due to the migration of wind blown sand. Due to the cohesive soils underlying the pilot channel and adjacent dense willow growth, channel scour in lower Redwood Creek will continue to be inhibited, reducing channel conveyance and drainage of the project site.

Given the increased flooding and threats to fish passage under No Action, we presume that NPS would continue to implement emergency maintenance measures, as described in Section 5.2.1. Therefore, for Year 50 conditions for the No Action Alternative, it is assumed the channel would be dredged as needed to maintain the current profile elevations (Figure 14). Dredging would be performed so that flooding on Pacific Way does not increase and the existing channel is not abandoned. NPS may also have to periodically dredge or re-excavate the pilot channel in response to deposition of wind blown sand in the channel. Based on Stillwater's (2003) estimate of current sediment delivery to the site and observed channel deposition at reoccupied cross-sections near Pacific Way Bridge, we estimate that under existing conditions the channel and floodplain trap 80% of the bedload and 25% of the suspended load. Using this trapping estimate, NPS would need to excavate approximately 500 cubic yards of sediment per year, on average, over the next 50 years to maintain the existing channel capacity in its present location and to prevent increased flooding.

7.2.1.2 Hydrology

The hydrologic regime under Alternative 1 would be similar to conditions measured in 2002-2003, varying seasonally depending on freshwater inflow rates from Redwood and Green Gulch creeks. High flows in the winter months and poor drainage of the project site would maintain the high winter groundwater elevations measured in 2003 (Figure 22). Groundwater elevations would likely continue to be just below the ground surface in the winter, saturating most of the project site downstream of Pacific Way from January through April (Figure 22).

Currently, the pilot channel thalweg is maintained year round at about +4 ft NGVD, setting the minimum groundwater elevation for the late summer months. With the end of the wet season in April, groundwater levels will decrease at a rate of 0.5 – 1.0 ft/month, reaching a minimum of +4 ft NGVD in September and October based on groundwater data collected in 2003 (Figure 22). Flows on Redwood Creek decrease to as little as 0.5 to 1.0 cfs in the late summer and early fall. Previous hydrologic and groundwater modeling showed that Redwood Creek can be expected to be completely dry in late summer or early fall once every 4 years (PWA 1995). Table B-1 summarizes the projected water balance for Alternative 1. During very low flow conditions, like the drought conditions experienced in September 1992, losses from evapotranspiration exceed inflows from Redwood Creek due to diversions at the MBCSD well, lowering creek water levels by 0.9 ft (Table B-1).

7.2.1.3 Flooding

High flows in the winter will continue to escape the channel upstream of Pacific Way, flowing down the low point of the valley and flooding Pacific Way at a depth of 1 to 3 feet between the bridge and Highway One. In a major flood event, channel avulsion is possible, and the main channel could reestablish itself along the low point of the valley through Green Gulch Pasture (see Figure 5).

Hydraulic modeling results for the No Action Alternative at Year 0 are shown for Q5 and Q50 on Figures 26 and 27, respectively. The modeling demonstrates that during 5-year events (1,600 cfs) and greater, the floodplain (all areas below + 11 NGVD) would be inundated. Since for Year 50 conditions we assumed NPS would actively dredge the channel to maintain the existing conveyance, the predicted water surface elevation at Year 50 (Figures 28 and 29) would be approximately the same as Year 0.

7.2.1.4 Impacts to Beach and Tidal Lagoon

Since scour in the pilot channel is currently constrained, the tidal lagoon may not be as efficiently flushed of sediment in the winter. Windblown sand will migrate inland expanding the beach to the edge of the existing pilot channel. Deposition over the long-term would further inhibit channel conveyance, increasing backwater and conveyance upstream.

7.2.1.5 Water Quality

Under the No Action Alternative, water quality conditions are likely to exhibit similar patterns as presented in Appendix B of Part I. The major water quality problem is related to extremes in late summer dissolved oxygen levels in most years related to higher nutrient levels, sunlight, and lower water exchange rates in the lowermost portions of the study area. These conditions are unlikely to change significantly by Year 50. Because of the episodic nature of beach closure and salt water intrusion, salinity extremes in the lower portions of the study area represent a natural disturbance common to the ecology of all estuarine systems. Although temperatures within the study area appear within the range suitable for salmon and other fish (Appendix B, Part I), temperature peaks in the lagoon area from summer through early fall will likely continue to limit freshwater fish production.

7.2.1.6 Vegetation/Terrestrial Habitats

Under the No Action Alternative, vegetation at Year 5 is likely to remain similar to existing conditions (described in Section 4.3.1 of Part I), with some evolution of the vegetation on site as it adjusts to groundwater changes resulting from the 2002 excavation of the pilot channel (e.g., riparian vegetation may expand). The structure and species composition of the mature riparian forest and scrub will be similar to existing conditions, with some new recruitment possible in the Alder Grove upstream of Pacific Way where long periods of inundation, which have resulted in die off of riparian vegetation in this area, will be avoided by channel maintenance activities. The seasonal wetlands in the Green Gulch Pasture fields will continue to support a mix of obligate wetland species such as tules (*Scirpus* spp.) and cattails (*Typha* spp.) in the wetter areas (closest to the creek channels), and more facultative wetland and upland species away from the creek channel in higher elevation areas. The brackish marsh area between the existing parking lot and the tidal lagoon will remain relatively the same, as would the dune scrub area to the south of the footbridge. Non-native species would continue to dominate disturbed areas, especially those in higher, drier areas, unless an aggressive program of weed maintenance and planting of native species is implemented.

This condition is unlikely to change significantly by Year 50. A slight lowering in the groundwater table due to continued maintenance of the channel may lead to the establishment of pioneer riparian species such as willows (*Salix* spp.) in place of the emergent wetland species along the eastern side of the levee road, expanding slightly into the Green Gulch Pasture. In addition, the Alder Grove upstream of Pacific Way would likely have develop into a mature stand, especially since maintenance of the creek channel would reduce water levels from backing up and flooding the area for long periods of time, preventing die off of mature trees and promoting recruitment of new trees. The existing restored dune scrub area (0.1 acre) would remain similar in size, at a minimum, and is likely to continue to maintain a plant community with low species richness, percent cover, and a high percentage of non-native species.

7.2.1.7 Suitability for Focal Species: Fish

Current habitat conditions for coho salmon and steelhead are described in 4.3.2.5 of Part I. Lower Redwood Creek and the upper portion of the tidal lagoon are believed to provide important rearing habitat for juvenile coho and steelhead when suitable flow conditions exist. Juvenile rearing habitat, aquatic macroinvertebrate food resources, and water quality (primarily temperature and dissolved oxygen), have been identified as factors potentially limiting salmonid production in the project area (PWA 2003). The availability of pools, used as key rearing habitat by juvenile coho salmon, is an especially important habitat feature. Each of these factors in the project area is detrimentally affected by low stream flows and, with the possible exception of water quality, are also influenced by sediment deposition. Low stream flows and bed aggradation caused by sedimentation may also interfere with upstream passage by adult coho salmon and steelhead, although Smith (*pers. comm.*, 2004) notes this is unlikely. The continued confinement of the stream channel by levees and the static channel alignment above Pacific Way Bridge will limit future recruitment of instream wood and will continue to hinder natural channel-floodplain interactions during high flows, and therefore are likely to limit floodplain cover and velocity refugia important for winter rearing. Thus, even though the No Action alternative would maintain the greatest amount of wetland acreage over time (Table 7-3), these areas may not be accessible by fish species for winter/spring rearing habitat.

Future stream flows under this alternative—and the resultant effects on salmonid habitat suitability and production—are expected to remain similar to current conditions. Habitat and food availability, as well as water quality and upstream passage, are likely to limit salmonid production during low flow periods. Continued sediment deposition in the project area under this alternative is expected to reduce open water habitat area, pool volume, and overall aquatic habitat complexity, resulting in less suitable habitat for winter rearing by salmonids. Excavation of accumulated sediment for flood control, however, can be expected to periodically restore previously existing amounts of open water habitat and temporarily increase pool volume. However, the dryback and diversion around the excavation site may affect summer rearing at the site (J. Smith, *pers. comm.*, 2004). Substrate homogeneity caused by excess fine sediment deposition, together with ongoing sediment removal, would likely suppress invertebrate production.

7.2.1.8 Suitability for Focal Species: California Red-legged Frog

The current habitat conditions for the federally listed threatened California red-legged frog (*Rana aurora draytonii*) are discussed in Section 4.3.2.1, Part I. Recent surveys by Fellers and Guscio (2003) found that adult red-legged frogs were present in small numbers ($\leq$ 10) in the area, and that the frogs were reproducing in the area. Most of the frogs were found in the dense cattails just east of the levee road (in the Green Gulch pasture where the unnamed tributary and Green Gulch Creek enter Redwood Creek), indicating that a fairly small portion (approximately 1 acre) of the total site area is being used. Unfortunately, successful reproduction was unlikely, as the area where egg masses were found dried before tadpoles would have had a chance to metamorphose (Fellers and Guscio 2003). No frogs, egg masses, or tadpoles were found in the Green Gulch drainage upstream of Green Gulch Pasture, nor were they observed in Redwood Creek upstream of Highway One.

It was noted that more recent efforts by NPS to improve drainage in the area (i.e., dredging downstream of the footbridge) have lowered surface water in lower Redwood Creek and groundwater in the Green Gulch Pasture, degrading habitat for red-legged frogs and potentially threatening their persistence at the site (Fellers and Guscio 2003). NPS has implemented interim measures (hydraulic control structures on Green Gulch Creek and the unnamed tributary) to encourage ponding and growth of cattails in order to improve site conditions for the frog in the short-term. These actions would likely need to continue under the No Action Alternative in order to maintain suitable habitat for red-legged frog breeding.

7.2.1.9 Suitability for Focal Species: Birds

Current levels of bird diversity and productivity will likely continue under the No Action Alternative. Diversity of bird species associated with wetlands and open water habitats will continue to be limited by habitat quality (in the case of wetlands) or quantity (open water). However, with the possible exception of cavity-nesting birds, conditions for riparian associated species should improve slightly through Year 50 as the Alder Grove upstream of Pacific Way develops into a mature stand in the areas currently impacted by recent high water levels. There would likely be a gradual loss of existing alder snags over the next 50 years, and thus a decrease in habitat for cavity-nesting birds. However, new recruitment of snags would likely begin in 50–100 years, as red alders tend to reach maturity at about 60 – 70 years, and maximum age is approximately 100 years (Harrington et al. 1994). The width of functional contiguous riparian corridor will continue to be limited by the existing boundaries of the riparian habitat and the reduced quality of much of the existing wetlands on the site relative to the enhanced wetland quality expected under the other alternatives.

7.2.2 Alternative 2 – Creek Restoration

Alternative 2 would create a restored, self-sustaining riparian system with improved channel-floodplain connectivity and reduced hydraulic constraints (Figures 8 and 9). This alternative represents the endpoint of the evolutionary trajectory of the restored large lagoon system (Alternative 4). Because this alternative seeks to create a riparian system in a state of equilibrium, significant habitat changes are not anticipated over the 50-year planning horizon (Figure 23). Under this alternative, much of the site is expected to evolve from degraded wetlands to mature riparian forest due to lowering of the groundwater table in the Green Gulch pasture.

7.2.2.1 Geomorphic Evolution

The restored channel under Alternative 2 would have improved hydraulic conveyance and sediment transport relative to No Action. The major geomorphic changes anticipated over the 50-year planning horizon are floodplain deposition and aggradation of the channel bed in response to sea level rise, about 0.7 feet over the next 50 years. During flow events greater than the 1.5 to 2-year flow, flows would overtop the channel and inundate the floodplain, depositing suspended sediment as flow velocities rapidly decrease. Deposition would be concentrated in natural levees and in topographic depressions on the floodplain, including the backwater channel and Green Gulch Creek. However, large flood events would likely scour sediment deposited in these secondary channels. Site aggradation over the 50-year planning horizon is based on about 30% of the bedload supply for channel deposition and about 15% of the suspended sediment supply for floodplain deposition (a total of about 22,000 cubic yards over 50 years, see Section 7.1.1). Figure 23 depicts the project site at Year 50. The major changes from Year 0 include maturation of the riparian habitat in Green Gulch pasture and narrowing of the marsh habitat along Green Gulch Creek due to sediment deposition. In a major flood event, channel avulsion is possible, and the main channel could reestablish itself along the alignment of either the backwater channel or Green Gulch Creek, converting the main channel into a new backwater channel. However, the low vegetated levees planned for Alternative 2 would reduce the likelihood of channel avulsion.

7.2.2.2 Hydrology

The hydrologic regime of Alternative 2 would vary seasonally depending on freshwater inflow rates from Redwood Creek. The lower channel thalweg and improved conveyance would enhance drainage of the project site and lower groundwater elevations. Overall, groundwater elevations are anticipated to be about 1 foot lower than as measured in 2003 (Figure 22). As flows in Redwood Creek subside in the spring and early summer, deposition in the back beach channel from windblown sand would raise thalweg elevations to about mean higher high tide (about +3 ft NGVD), setting the minimum groundwater elevation upstream. Based on 2003 groundwater data, groundwater levels would decrease at a rate of 0.5 – 1.0 ft/month, reaching a minimum of 3 to 4 ft NGVD in September and October (Figure 22). Flows on Redwood Creek can decrease to as little as 0.5 to 0 cfs in the late summer and early fall. Previous hydrologic and groundwater modeling showed that Redwood Creek could be expected to be completely dry in late summer or early fall once every 4 years (PWA 1995). However, while groundwater levels may be reduced by about 1 foot due to the lower thalweg elevation downstream of the pedestrian bridge, the channel thalweg will be lowered from 1 to 6 ft through Green Gulch pasture, reducing the frequency of no flow in the channel below No Action conditions.

Table B-2 summarizes the projected water balance for this alternative. The water balance for Alternative 2 shows no significant changes from existing conditions, since the percentage of open water is only slightly larger under Alternative 2 and the existing wetland plants are replaced with young riparian habitat, keeping evapotranspiration losses about the same. During very low flow conditions, as in September 1992 when average flow velocities was 0.04 cfs, diversion at the MBCSD well could lower creek water levels by 0.8 ft (similar to conditions under No Action).

7.2.2.3 Flooding

The new channel would be designed to convey the 1.5 to 2-year flow (570 to 805 cfs). Under higher flow conditions, floodwaters would overtop the channel banks and inundate the floodplain between Highway One, Lagoon Drive, and Pacific Way. Overbank flows would drain to the backwater channel on the western floodplain and reconnect with the main channel adjacent to the parking lot. On the eastern floodplain, overbank flows would be intercepted by Green Gulch Creek, which also reconnects to the main channel of Redwood Creek adjacent to the parking lot. The new Pacific Way Bridge would be designed to provide at least 1 foot of freeboard during the 50-year event (see Section 5.3.1.5).

Hydraulic modeling of Alternative 2 showed that the increased channel capacity and decreased channel roughness of the restored channel would improve hydraulic conveyance and reduce flooding relative to the No Action Alternative. Predicted water surface profiles for Q5 and Q50 are shown at Year 0 (Figures 26 and 27, respectively) and at Year 50 (Figures 28 and 29, respectively). The change in water surface elevation as compared to the No Action Alternative is summarized in Table 7-4. Under both Q5 and Q50 conditions, water levels would decrease by approximately 0.2 to 1 foot immediately upstream of the Pacific Way bridge, by roughly 0.5 ft between Pacific Way Bridge and the parking lot and would not change downstream of the parking lot. Alternative 2 would include the new causeway bridge discussed in Section 5.3.1.5 to prevent flooding of Pacific Way and effects of the bridge on upstream water surface levels. By Year 50, the reduction in Q50 flood levels would decrease from approximately 1 foot to 0.5 foot due to the channel and floodplain deposition anticipated in response to sea level rise.

Table 7-4. Predicted Change in Water Surface Elevation under Alternative 2

Alternative 2 vs. No Action	Year 0		Year 50	
Location	**Q5**	**Q50**	**Q5**	**Q50**
Pacific Way	-1.1	-1.1	-0.2	-0.5
Upstream of Parking lot	-0.6	-0.7	-0.6	-0.7
Downstream of Parking lot	No change	No change	No change	No change

7.2.2.4 Impacts to Tidal Lagoon

The relocation of lower Redwood Creek channel to its historical alignment along the back beach would increase the depth of scour during the winter, increasing flushing of the tidal lagoon in the winter, increasing tidal exchange and improving water quality.

7.2.2.5 Water Quality

Under the Creek Restoration Alternative, short-term impacts related to turbidity from bare surfaces following construction would likely be limited to the first year or two. By Year 5, tree growth would be insufficient to provide substantial shade in the lower portions of the site and may lead to slightly increased water temperatures relative to the No Action Alternative. Development of wetland plant community and soils would provide improved nutrient removal and improved dissolved oxygen (DO) conditions in the lowest portions of the site. Within the lower portion of the site and the backwater channel, periodic salt water intrusion combined with below normal spring outflows may continue to contribute to density stratification of high salinity and low DO water beneath a freshwater lens. Depending upon wind and sunlight, daytime warming of the salt water layer may not be lost to nighttime radiative cooling at certain times of the year, contributing to a warm saline lens beneath a cooler freshwater surface layer.

By Year 50, water quality conditions are likely to exhibit only slight improvements relative to the No Action Alternative and existing conditions (see Appendix B, Part I. for more details on current conditions). However, development of extensive riparian forest over-story will provide shade and help maintain cool water habitat along the lower Redwood Creek corridor. These improvements in shade combined with enhanced nutrient processing by the developed wetland and riparian community will reduce oxygen and temperature extremes that occur presently and that would continue under the No Action Alternative.

7.2.2.6 Vegetation/Habitats

Under the Creek Restoration Alternative, the site would be graded to promote establishment and maintenance of approximately twice the acreage of existing riparian vegetation, with a significant loss of seasonal wetlands in the Green Gulch Pasture area compared to the No Action Alternative (Table 7-3). A small amount of existing riparian vegetation (1.3 acres) in the Green Gulch Pasture just downstream of Pacific Way initially would be lost to accommodate the construction of the new Redwood Creek channel, although the area would eventually recolonize with riparian vegetation. By Year 5 the new riparian vegetation would have established but would not have matured to the point where it would produce significant shading of the creek channels or high quality habitat for nesting riparian bird species. The small (0.9 acre) remaining wetland area at the confluence of Green Gulch and Redwood creeks would be more hydrologically/geomorphically connected to the new Green Gulch Creek channel, improving the natural processes that form and sustain a gradient of wetland types over time. In addition, this wetland would be modified to enhance habitat conditions for California red-legged frog breeding and rearing.

Between the parking lot and the tidal lagoon, rubble and fill material would be removed to allow for natural dune evolution to occur, but the existing brackish marsh in this area would still be largely intact at Year 5 (although it would eventually be completely replaced by dune scrub by Year 50). Development of a healthy native dune scrub community would be unlikely to occur unless an active weed management program is implemented to control invasive non-native weeds that currently occur in the area. Although control efforts would likely need to be most intensive during the first 5 to 10 years of restoration, some level of weed management would need to continue through Year 50 to insure proper functioning of the dune scrub community.

By Year 50 the new riparian areas downstream of Pacific Way would have matured, providing many ecological functions such as stream shading, sources of large woody debris and other organic matter (e.g. leaf litter) inputs to the aquatic ecosystem, and habitat for various terrestrial riparian wildlife species. The Alder Grove upstream of Pacific Way would similarly have matured. The graded wetland area at the confluence of Green Gulch and Redwood creeks would have partially filled in with sediment, reducing its area from 0.9 acres in Year 5 to 0.5 acres in Year 50. This natural aggradation would result in the transition from emergent wetland to higher elevation riparian plant species around the perimeter of this wetland. A total of approximately 22 acres of mature riparian forest and scrub are expected to be present in Year 50 (Table 7-3). Finally, it is anticipated that the new dune scrub area between the tidal lagoon and the parking lot would expand, completely replacing the existing brackish wetland, for a total of 2.6 acres of dune habitat within the project boundary.

7.2.2.7 Suitability for Focal Species: Fish

This alternative is expected to provide greater ecological function for salmonids than the No Action Alternative through improved channel-floodplain connectivity and reduced hydraulic constraints. In addition to eliminating the need for maintenance dredging, creation of a less confined Redwood Creek channel, Green Gulch tributary channels, and a new backwater channel would increase the amount of open water and edge habitat available for salmonid rearing by 0.3 acres, which would be maintained over time (Table 7-3). Low velocity aquatic habitat for winter rearing would be immediately available in the backwater channel created under this alternative, with only a minimal reduction through Year 50 due to infilling. The final design and excavation of the backwater channel would need to consider the possible risk of juvenile stranding as the backwater dries.

Due to improved channel-floodplain connectivity under this alternative, additional winter rearing habitat would be available on the adjacent floodplain and emergent wetland when high winter flows overtop the channel banks and berms (expected at a 2-year flow event). Although habitat area under Alternative 2 would increase immediately following construction, the amount of instream and overhead cover for rearing salmonids would be low at Year 5, except for preserved riparian vegetation on the west bank of the existing backwater channel. Cover would improve gradually as vegetation grows and habitat complexity increases through natural processes.

Increased scour in the new Redwood Creek channel is expected to create and maintain complex aquatic habitats, including pools used for adult holding and juvenile rearing. Complex habitats and reduced deposition of fine sediments in the upstream portion of the project area should provide adequate aquatic macroinvertebrate production to support rearing salmonids and contribute to overall aquatic ecosystem function. Recruitment of LWD would initially be low following channel reconstruction and riparian revegetation (although recruitment potential upstream of Pacific Way is currently high due to the dead alders in the Alder Grove). Over the next 50 years, however, LWD recruitment is expected to increase relative to the No Action Alternative as ongoing bank scour and channel migration recruit maturing and senescing riparian trees. Additional riparian functions that may influence aquatic habitat quality for salmonids, including stream shading and organic matter input, are expected to follow a similar pattern, with low functionality at Year 5 increasing through Year 50.

The effects of water quality on salmonid rearing habitat under this alternative depend in large part on stream flow. Even with decreased groundwater levels (Table 7-2), flow depths in the reconstructed channel are expected to increase due to thalweg lowering. In addition to an increase in rearing habitat area, the new channel geometry and reduced rate of sediment deposition would increase the availability of cool water habitat with depth. Water temperature improvements would be minimal at Year 5 due to low levels of riparian shade following construction. However, without adequate flow, maintaining high DO conditions with depth will depend upon the presence of shade and reduced nutrient inputs form the surrounding watershed. By Year 50, shade from mature riparian vegetation is expected to provide improved water temperature and DO conditions relative to the No Action Alternative, thereby increasing habitat suitability for rearing salmonids. Additional effects of this alternative on water quality are discussed in 7.2.2.5.

7.2.2.8 Suitability for Focal Species: California Red-legged Frog

Under Alternative 2, a portion of the existing unnamed tributary and associated vegetation would be preserved to maintain some existing habitat for red-legged frogs. In addition, under Alternative 2, the proposed wetland/pond complex at the confluence of Green Gulch Creek and Redwood Creek would provide additional breeding and rearing habitat. The on-channel wetland/pond complex totals approximately 0.9 acres and would be excavated to elevation +5 feet NGVD and lower. This is less than the approximately 1 acre of existing habitat known to be occupied by red-legged frogs in the Green Gulch Pasture (Fellers and Guscio 2003) that would remain under No Action, however, habitat function and quality would be improved under Alternative 2. The final grading design should provide the necessary hydroperiod (*e.g.,* depth, duration, and frequency of inundation), vegetation, and microhabitat features necessary for breeding and rearing, as discussed in Section 5.3.1.6. In the near term the wetland/pond complex would be more contiguous with higher elevation riparian areas compared to the No Action Alternative, improving habitat function of the project site. Although natural sedimentation of the site is likely to re-occur, a portion of this site (0.5 acres) is anticipated to remain by Year 50.

7.2.2.9 Suitability for Focal Species: Birds

Current levels of bird diversity and productivity will likely continue under Alternative 2. Diversity of bird species associated with wetlands and open water habitats will be limited by habitat quantity, with wetland habitat becoming even more limited (only 0.5 acres) by Year 50 and the amount of open water habitat remaining similar to current levels. Conditions for riparian associated species may decrease slightly initially as the amount of mature riparian vegetation initially drops from the current 13.2 acres to 11.9 acres in Year 5, but then should steadily improve compared to the No Action Alternative as the area of new riparian vegetation present in Year 5 develops into mature stands by Year 50 totaling 22 acres. In addition, the length and width of contiguous riparian corridor would be greatest under this alternative, which should result in increased habitat quality as well as quantity for riparian associated species.

7.2.3 Alternative 3 – Creek & Small Lagoon Restoration

Alternative 3 would initially restore a wetland system consisting of approximately 6 acres of open water and 5 acres of emergent wetlands (Figures 10 and 11). Over the 50-year planning horizon, the small lagoons are expected to fill in, replacing much of the open water habitat with emergent wetland. At Year 50, the landscape is expected to evolve to be similar to the initial grading template for the Creek

Restoration Alternative, including a persistent backwater channel, but with more shallow wetlands in the filled lagoon areas (Figure 24).

7.2.3.1 Geomorphic Evolution

In Alternative 3, the channel of Redwood Creek is configured in the same manner as Alternative 2 to maximize sediment transport to the ocean. However, the small lagoons in Alternative 3 would act as efficient sediment traps. By Year 50, the small lagoons are anticipated to be filled with about 3 to 4 ft of sediment, transforming the open water habitat to emergent wetlands with a backwater channel along the western bank of the western small lagoon, resembling Alternative 2 in Year 0 (Figure 24). The channel in the project site would be designed to convey the 1.5 to 2-year flow (570 to 805 cfs), and any flows above this discharge would be expected to escape the channel banks and inundate the floodplain. Overbank flows would drain to the small lagoons on either side of the creek channel, reconnecting with the main channel adjacent to the parking lot. Sediment deposition would be concentrated in the two lobes of the small lagoon, as floodwaters collect in the small lagoons and water velocities drop. About 0.7 ft of channel and floodplain aggradation are also anticipated by Year 50 in response to sea level rise. We estimate that the under the Small Lagoon Alternative approximately 50% of the bedload and 30% of the suspended sediment load would be retained, resulting in a cumulative deposition of about 40,000 cubic yards over 50 years. In a major flood event, channel avulsion is possible, and the main channel could reestablish itself along the alignment of either of the small lagoons. However, the low vegetated levees planned for Alternative 3 would reduce the likelihood of channel avulsion.

7.2.3.2 Hydrology

The hydrologic regime of Alternative 3 would vary seasonally depending on freshwater inflow rates from Redwood and Green Gulch creeks. During the winter and spring, large volumes of water would enter the system and all areas below +5 feet NGVD would be inundated. During flood events, areas between +5 and +10 feet NGVD would also be inundated. Groundwater elevations would be similar Alternative 2, ranging from a maximum of about +7 ft NGVD in the winter to a minimum of +3 ft NGVD in the summer and early fall (Figure 22). At Year 0 in the winter, water depths in the small lagoons would typically range from a maximum of 6-8 feet in the deepest portions of the lagoons to 0-2 feet in the fringe wetlands (Table 7-2). As inflows from Redwood Creek decline in the early summer, water levels would recede until they reached the elevation of the thalweg downstream of the pedestrian bridge, about +3 ft NGVD. At this time, about 9 acres would be inundated at depths ranging from 1 to 4 ft. By Year 50, the small lagoons will have become emergent wetlands that will only be inundated in the winter at depths of 4 to 5 feet.

At Year 0, the Small Lagoon would result in lower total evaportranspiration losses between the Pacific Way Bridge and the tidal lagoon relative to No Action. Table B-3 in Appendix B summarizes the projected water balance for Alternative 3. The water balance shows that inflows would be significantly greater than evaporation losses throughout the winter and early summer. In a drought year, such as 1992, losses could exceed inflows from August until the time of the first fall storms (Table B-3). Upstream diversions from Redwood Creek at the MBCSD well would only have a significant effect on the Small Lagoon during drought years. For example, in the dry summer months of 1992, elimination of the diversion would have resulted in no significant change in the lagoon water level despite the low creek flows. In wet years, inflows would exceed evaporation losses throughout the Year, and lagoon water depths would stay between 3 and 4 feet through the end of summer. By Year 50, the water balance for the small lagoon will be similar to Alternative 2 at Year 0.

7.2.3.3 Flooding

The channel in the project site would be designed to convey the 1.5 to 2-year flow (570 to 805 cfs), and any flows above this discharge would be expected to escape the channel banks and inundate the floodplain. Overbank flows would drain to the small lagoons on either side of the creek channel and rejoin the main channel flows adjacent to the parking lot. The new Pacific Way Bridge would be designed to provide at least 1 foot of freeboard during the 50-year event (see Section 5.3.1.5).

The Small Lagoon significantly increases flood conveyance and is anticipated to provide the second largest reduction in flood levels in comparison to the other alternatives. Based on hydraulic modeling of Alternatives 1, 2, and 4, water levels are expected to be decreased by about 2 ft immediately upstream of the Pacific Way bridge under Q5 and Q50 conditions and by about 1 ft between Pacific Way bridge and the parking lot under Q5 and Q50 conditions. Alternative 3 includes the causeway bridge discussed in Section 5.3.1.5 to reduce flooding of Pacific Way and to minimize increases in upstream water surface elevation. By Year 50, flood levels under Alternative 3 are expected to be similar to Alternative 2 under Year 0 conditions due to filling of the small lagoons and loss of floodplain storage.

7.2.3.4 Water Quality

Under Alternative 3, short-term impacts related to turbidity from bare surfaces following construction will likely to be limited to the first year or two. Nuisance algae blooms may also occur in this time frame from the exposure of previously sequestered soil nutrients and the lack of water column shading by aquatic plants. With an outlet elevation at about +3 feet NGVD, saline water would enter the small lagoons during spring high tides, developing intermittent zones of brackish water. Since these events would coincide with periods of high freshwater inflows, most of the saline water would be rapidly flushed out of the system. Pockets of saline water could develop in deeper areas of the ponds, especially during the spring when freshwater flushing would be less frequent. Wind-mixing of bottom layers of salt water from increased wind and wave fetch relative to the no-action alternative may create brackish water throughout lagoon in rare circumstances with annual outwash of accumulated salt water during winter storms.

By Year 5, tree growth would be insufficient to provide substantial shade in the lower portions of the site and may lead to slightly increased water temperatures relative to the No Action Alternative. Development of wetland plant communities and soils will provide improved nutrient removal and improved DO conditions in the lowest portions of the site. Wind mixing of open water areas may provide a well oxygenated lagoon, which would help limit impacts of nutrient and bacterial loading from surrounding watershed.

By Year 50, water quality conditions will likely be improved relative to the No Action Alternative. The development of extensive wetland areas will provide improved nutrient removal, reduced algal abundance and may improve DO conditions in the remaining open water areas within the lagoons at the lowest portions of the site. Periodic salt water intrusion will continue to structure plant establishment in the developing wetland. The development of extensive riparian forest over-story will provide shade and help maintain cool water habitat along the lower Redwood Creek corridor. These improvements in shade and nutrient processing by the developed wetland and riparian community will reduce oxygen and temperature extremes that occur presently and that would continue under the No Action Alternative.

7.2.3.5 Impacts to Tidal Lagoon

The relocation of lower Redwood Creek channel to its historical alignment along the back beach would increase the depth of scour during the winter, increasing flushing of the tidal lagoon in the winter, tidal exchange and improving water quality. In addition, the reduced evapotranspiration losses under Alternative 3 would increase freshwater flows to the tidal lagoon. In drought years, this increased flow would cause the closed lagoon to diminish in size more slowly and improve water quality. In wet years, there would negligible benefits to the tidal lagoon from the reduced evapotranspiration losses.

7.2.3.6 Vegetation/Habitats

Although all the alternatives will provide significantly lower amounts of wetland habitat compared to the No Action Alternative, Alternative 3 provides the most wetland that will be sustained over time through natural infilling of the two small backwater lagoons. As with Alternative 2, there will be a small initial loss of existing riparian habitat just downstream of Pacific Way to accommodate the new Redwood Creek channel, and eventually a complete loss of the brackish marsh area between the parking lot and tidal lagoon by Year 50 to make room for additional dune evolution. Compared to the No Action Alternative, by Year 5 it is anticipated that there will be an increase in newly recruited (and/or planted) riparian vegetation at elevations greater than 5 ft NGVD of approximately 5.4 acres, and by Year 50 the total amount of mature riparian vegetation will be 17.1 acres, compared to 13.2 acres under the No Action Alternative. The evolution of the new dune area will be similar to that described under Alternative 2.

7.2.3.7 Suitability for Focal Species: Fish

This alternative, by creating two small backwater lagoons with low velocity open water habitat, provides the largest increase in off-channel winter rearing habitat for coho salmon and steelhead of any alternative. During high winter flows, lower velocity areas at the lagoon margins and in the flooded wetland and riparian vegetation adjacent to the lagoons would provide increased rearing habitat for overwintering coho salmon and steelhead relative to the No Action Alternative. The increase in open water habitat under this alternative, however, is temporary and by Year 50 the lagoons are expected to have filled in, leaving only a backwater channel and low-elevation floodplains to function as low velocity winter rearing habitat. Relative to the No Action Alternative this alternative provides considerably more open-water salmonid rearing habitat at Year 5, but only slightly more at Year 50.

Although the amount of open water rearing habitat under Alternative 3 would increase immediately following construction, the amount of instream and overhead cover for rearing salmonids would likely be low at Year 5, except for existing riparian vegetation preserved on the west bank of the west lagoon. Cover would improve gradually as vegetation grows and habitat complexity increases through natural processes. As the lagoons fill with sediment, however, decreasing water depth could offset the potential benefits of increased instream and overhead cover. Cover provided by deep water would diminish well before Year 50 and the risk of predation on juvenile salmonids by avian and terrestrial predators would likely increase

Increased scour in the new Redwood Creek channel is expected to create and maintain complex aquatic habitats, including pools used for adult holding and juvenile rearing. The small lagoons created under this alternative are not likely to function as holding habitat for adult salmonids during upstream migration. Complex habitats and reduced deposition of fine sediments in the upstream portion of the project area should provide adequate aquatic macroinvertebrate production to support rearing salmonids and contribute to overall aquatic ecosystem function. Recruitment of LWD would initially be low following channel reconstruction and riparian revegetation. Over the next 50 years, however, LWD recruitment is expected to increase relative to the No Action Alternative as ongoing bank scour and channel migration recruit maturing and senescing riparian trees. Additional riparian functions that may influence aquatic habitat quality for salmonids, including stream shading and organic matter input, are expected to follow a similar pattern, with low functionality at Year 5 increasing through Year 50.

The effects of water quality on salmonid rearing habitat under this alternative would be influenced by stream flow, the rate of sediment deposition in the lagoons, and vegetation characteristics. Assuming flow depths in the reconstructed channel increase under this alternative, additional benefit to salmonids would be realized compared to the No Action Alternative. In addition to an increase in rearing habitat area, the new channel geometry and reduced rate of sediment deposition would increase the availability of cool water habitat with depth. Water temperature improvements would be minimal at Year 5 due to low levels of riparian shade following construction. However, without adequate flow, maintaining high DO conditions with depth will depend upon the presence of shade and reduced nutrient inputs form the surrounding watershed. By Year 50, shade from mature riparian vegetation is expected to provide improved water temperature and DO conditions in the Redwood Creek channel relative to the No Action Alternative, thereby increasing habitat suitability for rearing salmonids. Additional effects of this alternative on water quality are discussed in Section 7.2.3.4.

7.2.3.8 Suitability for Focal Species: California Red-legged Frog

The wetlands associated with the margins of the lagoons under Alternative 3 provide a gradient of wetland habitats, and provide habitat continuity for dispersal to surrounding riparian corridors, thus improving habitat function for red-legged frogs when compared to the No Action Alternative. In addition, the emergent wetland vegetation is anticipated to expand with the sedimentation of the small lagoons over time. At Year 5, the aerial extent of standing water is expected to be much greater than under the No Action Alternative (6.2 acres of open water compared to 2.4 acres under the No Action Alternative), and the length of shoreline habitat is the greatest among all alternatives. Although deeper water areas are used by adults as refugia from predators (Gregory 1979, M. Jennings, *pers. comm.*, both as cited in Davidson 1993), the open water areas of the two small lagoons may provide habitat for fish species that prey on larval frogs, thus reducing the potential for reproductive success of the frog. Over time this problem will be less severe, since the two small lagoons will likely become filled in with sediment by Year 50 and may not provide the same value to predatory fish. In addition, periodic salt water intrusion (discussed in Section 7.2.3.4.) may create brackish water conditions unfavorable to red-legged frog breeding and this may limit suitable breeding habitat to the immediate vicinity of the freshwater inflows of Redwood and Green Gulch creeks.

7.2.3.9 Suitability for Focal Species: Birds

Bird diversity and productivity under Alternative 3 should be improved initially as the amount of open water habitat is increased to 6.2 acres. However, the area of open water habitat will drop to 2.6 acres by Year 50, similar to what will be present under the No Action Alternative. The amount of wetland habitat will be decreased relative to current conditions, but the quality and functioning of wetlands habitats should be increased under this Alternative which may help to maintain or enhance wetland bird diversity relative to the No Action Alternative. Conditions for riparian associated species may decrease slightly initially as the amount of mature riparian vegetation drops from the current 13.2 acres to 12.0 acres in Year 5, but then should steadily improve compared to the No Action Alternative as the areas of new riparian vegetation present in Year 5 develops into mature stands by Year 50 totaling 17.1 acres. The width of contiguous functional riparian/wetland corridor will tend to increase over time as the open water areas fill in and are converted to wetland habitat. This should help to increase habitat quality for riparian associated species relative to the No Action Alternative.

7.2.4 Alternative 4 – Large Lagoon Restoration

Alternative 4 would initially create a wetland system of approximately 10 acres of open water fringed by 6 acres of shallow wetlands (Figure 12 and 13). By removing hydraulic constraints and excavating approximately 170,000 cubic yards of sediment, this alternative would provide the greatest opportunity for the system to evolve on its own to a state of equilibrium. By Year 50, it is expected that roughly half of the lagoon would have been filled, forming a delta at the mouth of the creek and raising the bottom elevation by roughly 2 feet (Figure 25).

7.2.4.1 Geomorphic Evolution

The Large Lagoon would act as a sediment trap because of its large volume and slow flow velocities and would tend to retain a larger proportion of the delivered sediment compared to the other alternatives.

Treating the Large Lagoon as a small reservoir, the lagoon would retain approximately 100% of the bedload and 50% of the suspended sediment load, based on its capacity relative to the annual inflow volume of Redwood Creek (Brune 1953). Sediment would not be deposited uniformly over the area, but would be concentrated at the point where Redwood Creek discharges into the lagoon. A delta formed from the deposition of the bedload and coarse suspended sediment load would extend from the creek mouth into the lagoon. As the delta progrades into the lagoon, protected backwater areas would form on each side of the creek delta. Wind action and occasional high tidal flows would deposit sand into the seaward end of the lagoon. Most of this windblown sediment would be fine material that would easily be scoured and transported out of the lagoon by winter stormflows.

Figure 25 depicts the Large Lagoon and creek delta in Year 50, based on Stillwater's (2003) sediment budget and the trapping rate reported above. Sediment deposition would have reduced the maximum lagoon depths by 2 feet resulting in an average bottom elevation of +1 foot NGVD, while encroachment of the creek delta would have reduced the size of the open water by about 3 acres to 7 acres. At Year 50, about 75,000 cubic yards of sediment would have been trapped by the lagoon (roughly one half of the Year 0 excavation volume). However, sea level rise would likely offset about half of the 2 feet of deposition anticipated over the next 50 years. Therefore, minimum summer water depths would only decrease from +3 - +4 ft NGVD to +2 - +3 ft NGVD.

7.2.4.2 Hydrology

The hydrologic regime of Alternative 4 would vary seasonally depending on freshwater inflow rates from Redwood Creek. During the winter and spring large volumes of water would enter the system and all areas below +5 feet NGVD would be seasonally inundated. During flood events, areas between +5 and +10 feet NGVD would also be inundated. Groundwater elevations would be similar to Alternative 2, ranging from a maximum of about +7 ft NGVD in the winter to a minimum of +3 ft NGVD in the summer and early fall (Figure 22). At Year 0 in the winter, water depths in the lagoon would typically range from a maximum of 6-8 feet in the deepest portions of the lagoon to 0-2 feet in the fringe wetlands. As inflows decline in the early summer, water levels would recede until reaching the elevation of the thalweg downstream of the pedestrian bridge, about +3 ft NGVD. At this time, about 13 acres would be inundated at depths ranging from 1 to 4 feet. By Year 50, due to loss of capacity from sediment deposition, water depths would decrease by about 1 foot throughout the year (Table 7-2).

The Large Lagoon would result in only slightly higher evaporation losses between the Pacific Way Bridge and the tidal lagoon relative to No Action. Table B-4 in Appendix B summarizes the projected water balance for Alternative 4. Compared to No Action, the restored lagoon would have increased in evapotranspiration losses of approximately 2 acre-ft/year, with increased evaporation being slightly more than decreased transpiration. The water balance shows that inflows would be significantly greater than evaporation losses throughout the winter and early summer. In a drought year, such as 1992, losses could exceed inflows from August until the time of the first fall storms, and water levels could drop about 0.2 feet below the thalweg elevation of +3 ft NGVD. Upstream diversions from Redwood Creek at the MBCSD well would only have a significant effect on the Large Lagoon during drought years. For example, in the dry summer months of 1992, elimination of the diversion would have resulted in no significant change in the lagoon water level despite the low creek flows (Table B-4). In wet years, inflows would exceed evaporation losses throughout the year, and lagoon water depths would stay between 3 and 4 feet through the end of summer. At Year 50, the water balance is not expected to change significantly.

7.2.4.3 Flooding

The channel in the project site would be designed to convey the 1.5- to 2-year flow (805 cfs), and any flows above this discharge would be expected to escape the channel banks and inundate the floodplain. Overbank flows would simply drain to the large lagoon on either side of the creek channel. The new Pacific Way Bridge would be designed to provide at least 1 foot of freeboard during the 50-year event (see Section 5.3.1.5).

The Large Lagoon greatly increases conveyance and provides the largest reduction in flood levels in comparison to the other alternatives. Predicted water surface profiles for Q5 and Q50 are shown at Year 0 (Figures 26 and 27, respectively) and at Year 50 (Figures 28 and 29, respectively). The change in water surface elevation as compared to the No Action Alternative is summarized in Table 7-5. Under both Q5 and Q50 conditions, water levels would decrease by about 2.5 feet immediately upstream of the bridge, by roughly 1 foot between Pacific Way Bridge and the Parking lot, and no change downstream of the parking lot. Alternative 4 would include the new causeway bridge discussed in Section 5.3.1.5 to prevent flooding of Pacific Way and to minimize disturbances to upstream water levels. At Year 50, some of the flood benefits are reduced due to decreased storage capacity of the lagoon from sediment deposition.

Table 7-5. Predicted Change in Water Surface Elevation under Alternative 4

Alternative 4 vs. No Action	Year 0		Year 50	
Location	**Q5**	**Q50**	**Q5**	**Q50**
Pacific Way	-2.7	-2.5	-2.4	-2.3
Upstream of Parking lot	-1.0	-0.8	-1.0	-0.8
Downstream of Parking lot	No change	No change	No change	No change

7.2.4.4 Water Quality

Under the Large Lagoon Restoration Alternative, short-term impacts related to turbidity from bare surfaces following construction would likely to be limited to the first year or two. Nuisance algae blooms may also occur in this time frame from the exposure of previously sequestered soil nutrients and the lack of water column shading by aquatic plants. With an outlet elevation at about +3 feet NGVD, saline water would enter the Large Lagoon during spring high tides. The lower portions of the lagoon would therefore develop zones of brackish water. Since these events would likely coincide with periods of high freshwater inflows, most of the saline water would be rapidly flushed out of the wetland. Pockets of saline water could develop in deeper areas of the lagoon, especially during the spring when freshwater flushing would be less frequent. During the low-flow summer periods the lagoon outlet would be closed, preventing tidal inflows.

By Year 5, tree growth will be insufficient to provide substantial shade in the lower portions of the site and may result in slightly increased water temperatures relative to the No Action Alternative. Although lagoon water temperatures will be similar to those in Alternative 3, development of wetland plant communities and soils will provide improved nutrient removal and improved DO conditions in the lowest portions of the site. In rare circumstances, wind-mixing of bottom layers of salt water from increased wind and wave fetch relative to the no-action alternative may create brackish water throughout lagoon in some summers with annual outwash of accumulated salt water during winter storms. Wind mixing of open water areas may provide a well oxygenated lagoon, which would limit impacts of nutrient and bacterial loading from surrounding watershed.

By Year 50, water quality conditions will likely be improved relative to the No Action Alternative. The development of extensive wetland areas will provide improved nutrient removal, reduced algal abundance and improved DO conditions in the remaining open water areas within the lagoon at the lowest portions of the site. Periodic salt water intrusion will continue to structure plant establishment in the developing wetland. The development of extensive riparian forest over-story will provide shade and cool water habitat along the lower Redwood Creek corridor. These improvements in shade and nutrient processing by the developed wetland and riparian community will reduce oxygen and temperature extremes that occur presently and that would continue under the No Action Alternative.

7.2.4.5 Impacts to Tidal Lagoon

The relocation of lower Redwood Creek channel to its historical alignment along the back beach will increase the depth of scour during the winter, increasing flushing of the tidal lagoon in the winter, tidal exchange and improving water quality. In drought years, increased evaporation losses under Alternative 4 would decrease freshwater flows to the tidal lagoon by about 5% from August through October. The closed lagoon would diminish more rapidly, and lower inflows would increase the salinity and decrease dissolved oxygen levels. In wet years, there would still be freshwater inflow to the tidal lagoon throughout the dry season, and the increased evaporation would negligible effects on the tidal lagoon.

7.2.4.6 Vegetation/Habitats

Alternative 4 will result in a large increase in open water habitat at the project site, and thus the most construction disturbance and removal of existing riparian vegetation to excavate the large open water lagoon, yielding a narrower riparian corridor downstream of Pacific Way compared to the No Action Alternative by Year 5. As with Alternatives 2 and 3, there will also be a substantial loss of wetland habitat compared to the No Action Alternative, although wetlands will establish around the perimeter of the large lagoon, and will be sustained over time as sedimentation of the lagoon occurs. By Year 50 the riparian areas around the Redwood Creek channel will have matured, providing a relatively broad contiguous riparian corridor until the creek empties into the seasonally brackish lagoon. Periodic salt water intrusion into the lagoon will allow for some brackish marsh plant species to persist along the fringes of the lagoon.

7.2.4.7 Suitability for Focal Species: Fish

The Large Lagoon created under this alternative would provide increased open water habitat and more salmonid rearing habitat at Year 5 than the No Action Alternative and Alternatives 2 and 3. During high winter flows, lower velocity areas at the lagoon margins and in the flooded wetland and riparian vegetation adjacent to the lagoon would provide increased rearing habitat for overwintering coho salmon and steelhead. The extent of open water habitat, and potentially the amount of low velocity winter rearing habitat, would decrease from Year 5 to Year 50 as the lagoon filled with sediment and became smaller. Although the amount of open water rearing habitat under this alternative would increase immediately following construction, the amount of instream and overhead cover for rearing salmonids would likely be low at Year 5. Cover would improve gradually as vegetation grows and habitat complexity increases through natural processes. As the lagoon fills with sediment, however, decreasing water depth could offset the potential benefits of increased instream and overhead cover. Cover provided by deep water would diminish by Year 50 and the risk of predation on juvenile salmonids by avian and terrestrial predators would likely increase.

Increased scour in the new Redwood Creek channel upstream of the lagoon is expected to create and maintain complex aquatic habitats, including pools used for adult holding and juvenile rearing. Compared with the No Action Alternative, however, this alternative includes less river channel and thus a reduced amount of lotic habitat. The lagoon created under this alternative is not likely to function as holding habitat for adult salmonids during upstream migration. Complex habitats and reduced deposition of fine sediments in the Redwood Creek channel should provide adequate aquatic macroinvertebrate production to support rearing salmonids and contribute to overall aquatic ecosystem function. Recruitment of LWD would initially be low following channel reconstruction and riparian revegetation. Over the next 50 years, however, LWD recruitment is expected to increase relative to the No Action Alternative as ongoing bank scour and channel migration recruit maturing and senescing riparian trees. Additional riparian functions that may influence aquatic habitat quality for salmonids, including stream shading and organic matter input, are expected to follow a similar pattern, with low functionality at Year 5 increasing through Year 50.

The effects of water quality on salmonid rearing habitat under this alternative depend on stream flow and the rate of sediment deposition in Redwood Creek, as well as riparian and wetland vegetation characteristics. Assuming flow depths in the reconstructed channel increase under this alternative, additional benefit to salmonids would be realized compared to the No Action Alternative. In addition to an increase in rearing habitat area, the new channel geometry and reduced rate of sediment deposition would increase the availability of cool water habitat with depth. Water temperature improvements would be minimal at Year 5 due to low levels of riparian shade following construction. However, without adequate flow, maintaining high DO conditions with depth will depend upon the presence of shade and reduced nutrient inputs form the surrounding watershed. By Year 50, however, shade from mature riparian vegetation is expected to provide cooler water temperatures and improved DO conditions in the Redwood Creek channel relative to the No Action Alternative, thereby increasing habitat suitability for rearing salmonids. Additional effects of this alternative on water quality are discussed in Section 7.2.4.4.

7.2.4.8 Suitability for Focal Species: California Red-legged Frog

Although Alternative 4 also provides some fringe wetland habitat similar to Alternative 3, the larger open water area provides even more habitat for predatory fish (10 acres of lagoon), and a significant portion of this open water area is expected to be maintained over time (reduced to roughly 8 acres of lagoon by Year 50). In addition, the salinity levels in the lagoons, anticipated to remain brackish over time, may limit the amount of suitable freshwater wetland habitat available for frog breeding. The amount of suitable breeding habitat may be limited to areas in the immediate vicinity of the freshwater inflows of Redwood and Green Gulch creeks.

7.2.4.9 Suitability for Focal Species: Birds

Bird diversity and productivity under Alternative 4 should be improved initially as the amount of open water habitat is increased to 10 acres, creating a diverse assemblage of habitat types. However, the area of open water habitat will decrease to roughly 8 acres and the depth of the open water habitat will generally decrease by Year 50 due to sedimentation. The amount of wetland habitat will be decreased relative to current conditions, but the quality and functioning of the remaining wetland habitats should be increased under this alternative, which may help to maintain or enhance wetland associated bird diversity relative to the No Action Alternative. Conditions for riparian associated species may decrease initially as the amount of mature riparian vegetation drops from the current 13.2 acres to 9.6 acres in Year 5, but then should steadily improve compared to the No Action Alternative as the areas of new riparian vegetation present in Year 5 develop into mature stands by Year 50 totaling 15.4 acres. The width of contiguous functioning riparian corridor in the lower reach is reduced under this alternative due to the presence of the lagoon, however the general functioning of the riparian corridor should be enhanced relative to the No Action Alternative, which would help improve overall habitat quality for riparian associated species.

7.3 EVALUATION OF CONSTRUCTABLITY

The unique project setting of protected parklands located in a geographically isolated area presents certain challenges for construction. For all the restoration alternatives key issues for constructability will include construction phasing, scheduling and disposal of excess earth material. Construction needs to be implemented within sequencing and scheduling restrictions to provide advanced mitigation and to minimize wildlife disturbances. The potential impacts of construction on humans and wildlife will be evaluated further under the EIR/EIS. In this section, we discuss the basic construction approach to evaluate the constructability objectives established for the project (Section 3.3) and to provide a basis for the further EIR/EIS analysis.

7.3.1 Costs and Quantities

For each alternative, most of the design elements involve earthwork. As such, earthwork quantities were used as a surrogate for evaluating relative costs of the alternatives. In addition, estimates of cut and fill quantities were needed to help evaluate soil disposal options for excess soil discussed in Section 7.3.3. Net excavation and fill volumes for each alternative are summarized in Table 7-6 below. Major excavation items include channel and/or lagoon excavation, and removal of levee road and a portion of the parking lot. Required fill items include filling abandoned channels, constructing new creek berms, and improving trails and emergency staging areas. Fill required for improving trails and grading the emergency staging area was roughly estimated as 1,400 cubic yards for each alternative.

Table 7-6. Summary of Excavation Quantities

	Alternative 2 Creek Restoration (cubic yards)	Alternative 3 Creek & Small Lagoons Restoration (cubic yards)	Alternative 4 Large Lagoon Restoration (cubic yards)
EXCAVATION ITEMS			
1 New Main Channel			
a) Upstream of Pacific Way	1,500	1,500	1,500
b) Downstream of Pacific Way	2,300	2,300	500
c) Downstream of Footbridge	1,700	1,700	1,700
2 New Green Gulch tributaries	2,200	1,800	1,800
3 Backwater Channel	2,200	0	0
4 Wetlands Excavation(1)	6,000	0	0
5 Lagoon Excavation(s)	0	101,100(2)	172,200
6 Remove 90 feet of Parking Lot	1,500	1,500	4,200
7 Remove Levee Road	2,500	2,500	2,500
Total Excavation	**19,900**	**112,400**	**181,700**
FILL ITEMS (cubic yards)			
1 New Creek Berms	2,400	2,400	1,300
2 Fill Existing Main Channel	2,000	2,000	2,000
3 Fill Existing Green Gulch tributaries	1,800	1,800	1,800
4 Trails & Emergency Staging Area	1,400	1,400	1,400
Total Fill	**7,600**	**7,600**	**6,500**
NET EXCESS MATERIAL (cubic yards)			
Net Excess Material	**12,300**	**104,800**	**175,200**

(1) Excavation of weltand areas for Alternatives 3 and 4 are included under Lagoon Excavation.

(2) Based on 30,800 and 70,300 cubic yards excavation for the west and east lagoons, respectively.

As shown above, earthwork quantities for the creek restoration alternative roughly balance, resulting in roughly 12,000 cubic yards of excess material. However, both the lagoon alternatives would produce significantly larger volumes of excess material for disposal, roughly 105,000 and 175,000 cubic yards for Alternatives 3 and 4, respectively. Disposal options for excess material are discussed in Section 7.4.3.

Depending on the parking lot size and location selected, some excess excavated material may be used as fill to construct new parking areas. In addition, some parking lot options involve additional excavation of the existing parking lot. The following table summarizes the estimated fill and excavation volumes for various public access options and parking lot sizes. Earthwork volumes presented below should be added or subtracted to estimates presented in Table 7-6, depending on the public access option selected. Volumes were roughly estimated by assuming that parking areas would be raised or lowered by 3 feet.

Table 7-7. Additional Earthwork Volumes for Parking Lot Options

Option	Description	# of Spaces(1)	Excavation Volume(2) (cy)	Fill Volume (cy)
B	Minimum-sized Lot at the Beach	50	**3,500**	**0**
B	Maximum-sized Lot at the Beach	200	**0**	**7,900**
C	Maximum-sized Lot at Beach & Alder Grove	200	**0**	**7,200**
C or D	Minimum-sized Lot at Alder Grove	50	**6,100**	**2,600**
D	Maximum-sized Lot at Alder Grove(3)	132	**3,800**	**6,300**

(1) All options include at transit turnaround at the existing parking lot.

(2) Parking lot excavation, in addition to removal of 90 feet at the south end. See Table 7-6.

(3) Includes 14 spaces and transit turnaround at the beach and 118 spaces at the alder grove lot.

7.3.2 Project Phasing Approaches

The construction needs to be phased to ensure fish wildlife protection, reduce impacts to Muir Beach residents and businesses and provide advanced mitigation for impacts to protected habitats. In addition, resource agencies are likely to severely restrict the construction window for certain activities to minimize disturbances to wildlife and impact to water quality. Factors to be considered further when determining construction phasing for each alternative are discussed below.

Limited Construction Season. The construction season will be limited by scheduling restrictions determined by the resource agencies (USFWS, NMFS, RWQCB, CDFG, etc). Based on preliminary discussions with certain agencies, it is assumed that construction activities may be performed from June 1 and October 30 (5 months), while "in-channel" work is limited from June 1 to October 1 (4 months).

Coho Salmon and Steelhead Habitat. Although the timing of the construction window will prevent potential construction-related impacts to migrating coho salmon and steelhead, construction will be phased to protect rearing juvenile coho salmon and steelhead that may occur in the stream channels.

Currently, flows in Redwood Creek are bifurcated into two channels, with the left "borrow ditch" channel being the dominant channel (Figure 1). For Alternatives 2 and 3, the new channel and/or small lagoons could be excavated without disturbing the existing right (former main) channel, leaving this channel intact to provide habitat for juvenile rearing. Some excavation of a portion of the left "borrow" channel is required for both alternatives (to connect the backwater channel and west lagoon for Alternatives 2 and 3, respectively). Prior to excavation, the borrow channel would need to be physically isolated from the right channel and fish relocation would be required. The existing right channel could not be filled until flows are diverted to the new channel/lagoon system, and fish relocation has occurred. Filling the abandoned creek should be sequenced to minimize the potential for fish stranding or increases in turbidity.

For Alternative 4, a phased excavation of the large lagoon would be required to protect rearing juvenile fish. The new channel and west portion of the lagoon would need to be constructed initially without disturbing the existing channel. Flows could then be diverted to the new channel/lagoon system, allowing lagoon excavation near the existing channel to be completed. At this time, fish from the existing channel would be relocated to the active lagoon It should be noted that relocation of fish could potentially result in direct impacts to fish survival, and relocated fish may suffer additional impacts due to a lack of cover and food in the newly reconstructed lagoon. The second phase of lagoon excavation should be physically isolated from the active lagoon as long as possible. Sediment control measures (e.g. silt curtains, etc.) should be implemented prior to connecting the excavation area to the active lagoon. Further discussion with resource agencies is needed to determine permitting restrictions/requirements for this type of phased approach for lagoon construction.

If construction is phased over several years, creek restoration must also be sequenced so that there is a connected creek channel for fish upstream and downstream passage during the time period between construction seasons (October through May).

<u>California Red-Legged Frog Habitat.</u> Each of the alternatives involves disturbing at least a portion of existing California red-legged frog habitat in Green Gulch pasture (as described in Section 7.2.1.8). Advanced mitigation of frog habitat may be required by resource agencies prior to disturbing existing habitat either 1) directly by excavating in Green Gulch pasture and/or 2) indirectly by modifying the channel outlet (Section 5.3.1.3) and lowering groundwater elevation. If advanced mitigation were needed, off-channel ponds could be excavated in areas of the Green Gulch pasture. This advanced mitigation should consider the design elements described in Section 5.3.1.6 for enhancing red-legged frog habitat.

For all three alternatives, the off-channel ponds should be located a sufficient distance from the channel/lagoon excavation so that they are not disturbed during construction. For Alternative 2, the ponds could be located within the 0.9-acre wetland area in Green Gulch pasture, as long as the existing habitat along the unnamed tributary were not disturbed. For alternatives 3 and 4, less area of Green Gulch pasture is available for advanced mitigation because of the size of the lagoons. Consideration should be given to reducing the upstream extent of realignment of Green Gulch Creek and the unnamed tributary discussed in Section 5.2 (see Figures 10 and 12). Another alternative would be to reduce the size of the lagoon(s) to allow more space for off-channel ponds.

Access along Pacific Way. Because some Muir Beach residences can only be accessed from Pacific Way, this road must be maintained open for vehicle access throughout construction. To allow construction of the new bridge, a temporary road could be constructed to provide continuous vehicle access. The temporary road could be located on the southeast side of Pacific Way and would remain until the new bridge is completed. To maintain vehicle access during removal of the existing bridge, the existing channel would need to be partially filled to serve as a temporary roadway. In this case, the existing bridge should not be removed until the bridge is finished and flows have been diverted to the new channel.

Removal of Levee Road. Several factors should be considered in sequencing removal of the levee road. Currently this road serves the emergency access route to the beach. The new emergency access road along the site perimeter (shown on Figures 19 to 21) should be constructed prior to removal of the levee road. In addition, the levee road currently serves as a physical barrier between Redwood Creek and Green Gulch pasture. Maintaining the road as long as possible could be one interim measure for protecting fish during excavation in Green Gulch pasture (e.g. isolating the existing creek from construction zone). The levee road may not be suitable for construction access, especially as a haul route, due to its proximity to sensitive coho, steelhead and red-legged frog habitat areas. If this road were used for construction access, erosion and sediment measures would likely be required to protect adjacent habitat areas.

Excavation Dewatering. Dewatering of the new creek/lagoon excavations could lower water levels in the existing channel and Green Gulch pasture, adversely affecting fish passage and red-legged frog habitat. In addition, permitting requirements for treatment and discharge of removed water may be so restrictive that dewatering the excavation may be not be cost effective. As an alternative, land-based dredging equipment (such as hydraulic excavator or drag line) may be used for excavation.

Table 7-8 presents one suggested sequence for construction based on our current understanding of the factors described above. Construction activities that could be performed roughly within the same time are grouped together under stages. Construction could be scheduled so that more than one stage is performed within one construction season (June through October). On the other hand, certain stages, such as lagoon excavation, may need to be performed in multiple construction years.

Excavation production rates were estimated to help approximate the number of years needed to create the small and large lagoons. The maximum feasible production rate for excavation and truck loading is assumed to be roughly 500 cubic yards per day (Cooper, *pers. comm.*, 2004). Using this maximum rate, up to 40,000 cubic yards could be removed in a 4-month construction season. Note that the actual production rate would likely be less than the presumed maximum rate, given permit requirements, traffic restrictions and other implementation conditions.

This general sequence presented in Table 7-8 is based on the conceptual-level design and only a preliminary understanding of permitting requirements. Different approaches to construction sequence may be feasible.

Table 7-8. Suggested Construction Sequence for Alternatives 2 to 4

Stage	New Creek Channel	Wetland and/or Lagoon Excavation	Bridge Construction	Other Items
1	Ensure that the existing right channel of Redwood Creek has adequate depth and connectivity for fish habitat.	Excavate "mitigation ponds" in Green Gulch pasture to create red-legged frog habitat (if determined to be necessary).	Construct temporary bypass road on the east side of Pacific Way.	Construct temporary construction access. Remove parking lot and picnic area fill.
2	Excavate new Redwood Creek channel (upstream of footbridge).	Excavate backwater channel & new wetlands (Alt 2). Excavate small lagoons (Alt 3). Excavate east portion of large lagoon (Alt 4).	Construct new Pacific Way bridge.	Remove levee road.
3	Divert flows to the new creek channel/lagoon and relocate fish.	↓	↓	↓
4	Excavate new channel downstream of the footbridge.	Excavate west portion of large lagoon (Alt 4).	↓	Remove non-natives and debris at west end of beach.
5	Backfill former main Redwood Creek channel as needed.		Abandon existing Pacific Way bridge & widen road.	

7.3.3 Soil Disposal Options

The restoration alternatives would require offsite disposal of excavation volumes ranging from 12,000 to 175,000 cubic yards. A preliminary investigation of potential disposal methods and locations was conducted to help evaluate the feasibility of the project. Disposal methods are summarized as follows:

- Barging and deep offshore disposal
- Pumping and shallow offshore disposal
- Trucking and disposal within the watershed
- Trucking and disposal outside the watershed

Barging and offshore disposal is considered the most costly disposal option. This would require saturating excavated material to make a slurry, pumping to a barge and transporting the material several miles offshore for deep ocean disposal. For shallow offshore disposal, the slurry of excavated material would be pumped off-shore and disposed just beyond the wave zone. Although significantly less expensive than barging, shallow offshore disposal is considered infeasible because disposal would not be allowed within the Gulf of the Farallones National Marine Sanctuary. Trucking and land disposal is assumed to be less costly than barging and therefore the most feasible disposal method. For relative cost comparisons, costs for disposal options were roughly estimated at $100/cy minimum for barging, $5/cy for shallow offshore disposal and $30/cy for trucking (Cooper, *pers. comm.*, 2004). Actual disposal costs will vary, as trucking disposal costs are highly dependent on the transport distance and any charge for land disposal.

Disposal outside of the Redwood Creek watershed would require long truck hauls over narrow roads such as Highway One. In addition to the high disposal cost, this would involve extensive environmental impacts from the increased truck traffic and emissions. Depending on the disposal location, the haul distance may limit the number of truck trips per day, thereby prolonging the construction schedule and potentially increasing costs.

Ideally excess soil could be disposed at offsite construction or restoration sites within Marin County. The potential for this type of opportunistic soil disposal is better evaluated closer to implementation because it is highly dependent on the construction schedule of both projects. However, tidal restoration sites that were preliminarily identified as potentially needing fill include the Bel Marin Keys and Hamilton Army Airfield sites in Navato, California. If no other suitable disposal locations were identified at the time of construction, soil could be disposed at the Redwood Landfill in Navato; however, this option would be more costly, adding roughly $15 to $20 per cubic yard for disposal.

Because of the costs and impacts associated with trucking outside of the watershed, potential disposal sites within the Redwood Creek were preliminarily identified for further consideration. Potential disposal locations from the 1994 EA are shown on Figure 30, and a preliminary screening of these sites is summarized in Table 7-9. Each site is either a natural floodplain or wetland, and fill disposal at such sites is generally not consistent with watershed management goals. Any future consideration of nearby fill disposal should include: an analysis of environmental impacts, discussing approval requirements with property owners, and a cost-benefit analysis of on-site disposal versus off-site disposal. Each site and potential soil disposal issues are described in more detail below.

Table 7-9. Potential Disposal Locations

Potential Disposal Location	Estimated Capacity (cubic yards)	Screening Comments
1. Green Gulch Fields 6 and 7	7,000 – 13,000	Approval needed from Green Gulch Farm. A portion of Field 7 is within the potential restoration area. Field 7 and a portion of Field 6 are jurisdictional wetlands under Section 404 of the Clean Water Act.
2. Small Horse Paddock	750	Approval needed from Green Gulch Farm. Limited disposal in this area would be consistent with the restoration alternatives and continued operation of Ocean Riders.
3. Former Banducci Fields	16,000 - 27,000	Fill could be placed in the upper field setback 100 – 200 feet from Redwood Creek. Larger volumes of fill placement in the lower field considered incompatible with ongoing floodplain restoration.
4. Santos Meadows	N/A	California State Parks does not support the use of Santos Meadows for fill disposal. This site has been eliminated from further consideration.
5. Former Ballfield	1,800 – 3,600	Fill could be placed to fill drainage depression along Highway 1, consistent with future restoration possibilities. Larger volumes of fill placement considered incompatible with floodplain restoration.
6. Onsite Uplands adjacent to Highway One	1,800	Approval needed from Green Gulch Farm. Limited disposal in this area would be consistent with the restoration alternatives. Disposal of significantly larger soil volumes would be incompatible with floodplain restoration.

7.3.3.1 Green Gulch Fields 6 And 7

These are the two lowest fields operated by the Green Gulch Farm and would be adjacent to the restored wetlands. Field 6 is currently fallow but may be used for farming in the future. Field 7 is used for horse pasturing. Part of Field 7 would be included in the restored wetland.

Together Fields 6 and 7 could provide approximately four acres available for soil disposal, with elevations ranging from +12 feet NGVD near the proposed wetland to +25 feet NGVD at the top of Field 6. Excavated material could be placed to raise the south end of the field by approximately 2 to 4 feet, tapering down so that the north end of the field remains at +26 feet NGVD. The south end of the field could then slope down towards the edge of the restoration project at about 10:1 or flatter. Given these assumptions, the fields could accommodate approximately 7,000 to 13,000 cubic yards of excavated material (based on 4 acres an average of 2 feet deep).

This site has several constraints that may preclude its use for fill disposal. Major constraints include:

- The fields are owned by Green Gulch Farm, who wishes to preserve future opportunities for farming. Voluntary support from Green Gulch Farm would be required before these fields could be considered for disposal.
- These fields are currently part of an organic farming operation. Soil texture and chemical content, therefore, must be consistent with continued organic agricultural use. Also, placement of the fill and alteration of field drainage could not impact current or future potential agricultural uses of the fields.
- These fields are in close proximity to Green Gulch buildings and gardens. Noise from soil disposal and grading could impact conditions needed for Green Gulch's Zen practice and teaching.
- Field 7 and at least portions of Field 6 are jurisdictional wetlands under Section 404 of the Clean Water Act. These fields are also within the floodplain of Green Gulch Creek and are adjacent to Green Gulch Creek and an unnamed, channelized tributary to Big Lagoon. Disposal of soil at these sites would require permits and measures to avoid, minimize, and mitigate impacts to wetlands, the creeks, and the adjacent riparian corridors.

7.3.3.2 Green Gulch/Ocean Riders Horse Paddock

The horse paddock is located across Highway One from Golden Gate Dairy on property owned by Green Gulch Farm. This horse paddock could remain undisturbed under all the restoration alternatives. The site is currently used by Ocean Riders for turning out horses. Ocean Riders would like to increase the elevation of the site by approximately two feet so that it could support up to four horses year-round. Approximately 750 cubic yards of soil could be used to raise the horse paddock by 2 feet.

Potential constraints and considerations for soil disposal at this site include:

- The site is currently jurisdictional wetland under Section 404 of the Clean Water Act. Measures would be required to avoid, minimize, and mitigate impacts to wetlands from soil disposal.
- Remnant fences and other structures at the site may be culturally significant. Placement of soil at this site must consider potential impacts to cultural resources.
- The recently identified archaeological site is within or near the horse paddock. It should be confirmed that fill placement would not disturb the archaeological site.

7.3.3.3 Former Banducci Fields

In late 2003, NPS completed the first phase of floodplain restoration on the Banducci site, which included the removing the levee on the west bank of Redwood Creek to encourage channel-floodplain interaction. Any fill placed in this lower portion of the former Banducci fields would be inconsistent with NPS's goals of floodplain restoration. However, the upstream portion of this site could be used for limited soil disposal, as discussed in feasibility analysis for the Banducci Project (PWA 2002). Approximately two acres of this upstream area were used to dispose approximately 4,000 cubic yards of soil from the 2003 floodplain restoration project.

Allowing a 100- to 200-foot buffer from Redwood Creek, approximately 3.2 acres in the upper Banducci field could be available for soil disposal. If the depth of fill varied from 2 feet near the channel to up to 10 feet near the hillslope, the average fill depth would be 6 feet. Assuming an average depth of 4 to 6 feet, and accounting for lost capacity from recent fill placement, this location could accommodate 16,000 to 27,000 cubic yards of soil.

This site has several constraints that may preclude its use for fill disposal. Major constraints include:

- This site is adjacent to Redwood Creek and an unnamed tributary. Disposal of soil at this site would require measures to avoid, minimize, and mitigate impacts to the creeks and the adjacent riparian corridors. Adequate setbacks from the creek would be required to minimize flood hazards and impacts on the geomorphic stability of the creek.
- Access would be on a dirt road that enters Highway One about 1800 feet from Pacific Way. This road would probably need to be raised and improved. There is potential to use excavated gravel and coarse material for this purpose. The longest truck haul would be approximately 5,800 feet.

7.3.3.4 Santos Meadow (State Park Lands)

Santos Meadow is owned by Mt. Tamalpais State Park and provides an equestrian riding ring, group camp, and open pasture that are currently used by park visitors. This 7.4-acre site is also used by the Muir Beach Volunteer Fire Department for parking during their annual fundraiser and is located adjacent to the well that provides domestic water to the community of Muir Beach.

California State Parks has indicated that they do not support the use of Santos Meadows for disposal of excess fill from the Big Lagoon project (Lindberg, *pers. comm.*, 2004). Therefore, Santos Meadows has been eliminated from further consideration as a potential disposal site.

7.3.3.5 The Ballfield Area In Lower Franks Valley

The former ballfield area is located just upstream from the project site, at the intersection of Highway One and Franks Valley Road. The area is about 5.5 acres of fallow fields that are currently overgrown with grasses and coyote brush. A 2 to 5-foot levee currently separates the entire field from the creek.

The eastern corner of the ballfield currently forms a topographic depression. The site is owned by NPS and has potential for future floodplain restoration by removal of existing levees. If the creek channel were reconnected with the ballfield, the depressional area would present a drainage problem under normal storm events. Placement of 1 to 2 feet of fill in this area would address this drainage issue and would not be incompatible with future plans for restoration. Placing 1 to 2 feet of fill in this roughly 1.1-acre area would provide 1,800 to 3,600 cubic yards of disposal.

However, if the ballfield site were restored, a berm may need to be constructed along Highway One to prevent the road from being flooded more frequently. A small portion of fill from the Big Lagoon site could be used to supplement material from onsite levee removal to construct this berm. Access would be directly off of Muir Woods Road, with a truck haul distance of about 7,500 feet. Alternatively, fill removed from berms along Redwood Creek in the ballfield reach might be placed at this location.

7.3.3.6 Green Gulch Pasture Along Highway One

There is little opportunity for onsite fill placement because most of the site is already sensitive habitat. One potential disposal location is the existing slope between Highway One and the access road along the north boundary of Green Gulch pasture. Fill material could be placed in this area to flatten the south embankment of Highway One. The existing embankment is roughly an average of 9 feet high and sloped at 2:1 (horizontal: vertical). Material could be placed along a 600-foot length to widen the embankment by 20 feet and flatten the slope to roughly 4:1. For each alternative it was assumed that 1,800 cubic yards could be placed to these dimensions without negatively impacting with the restoration design. In addition to obtaining Green Gulch's approval, any fill placed in the Highway One right-of-way would require Caltrans approval through an encroachment permit. The Green Gulch Farm access road along Highway One would need to be reconstructed in the fill area. This disposal location would require minimal hauling, and would be one of the least expensive disposal alternatives.

8. EVALUATION OF PUBLIC ACCESS OPTIONS

The four public access options were evaluated for two basic issues, visitor access and the quality of visitor experience. Assessing visitor access incorporates several factors, including parking, vehicle access, connections between the parking/drop-off area and the resource, and trails. The evaluations try to address the following questions: Would parking lots accommodate an appropriate number of vehicles—as set forth in the CTMP? Would they intrude, visually or audibly, on the character of the site? Would visitors' vehicles and trail users be able to travel safely to the site and parking lots? Would emergency vehicles have a way to serve both sides of the creek that bisects the site? Would the system of roads minimize conflicts between visitor traffic and the residents? Would foot-trails be designed for universal access to the extent feasible, and give to users a route safe from vehicle traffic?

The evaluation of visitor experience, too, includes various aspects. Most visitors come to enjoy Muir Beach itself, so whether the design of public facilities would enhance the use of the beach would be an important consideration. Would visitors and residents also be able to experience the forests, wetlands, open water, and other habitats created in the restoration alternatives, without disturbing the natural processes intended to develop? Would interpretive facilities educate visitors with good on-site examples about natural coastal processes, watershed issues, the long and rich history of human habitation at the site, and recent efforts at a balanced restoration? And lastly, would visitors be able to make their own discoveries and to form attachments to the place?

8.1 Option A – No Action

8.1.1 Visitor Access: Parking

The existing 175-car parking lot is adequately sized for the peak-season weekday demand and the shoulder-season weekend demand of 160 vehicles each, according to the CTMP. However, it does not satisfy the current peak-season weekend demand of 200 vehicles. At these peak times, visitors park illegally along the shoulders of Pacific Way and Highway One. These roads are not designed to accommodate two travel lanes plus parking and sidewalks, and illegal parking creates congestion and unsafe conditions for drivers and pedestrians alike.

The parking lot itself is configured in a way that impinges upon the creek at the transitional zone between the inland wetland/meadow area and the beach/dune area. This encroachment constrains the natural flow of the creek and impedes a sustainable, healthy evolution of the natural processes at the site.

8.1.2 Visitor Access: Traffic Circulation

Access to the existing public parking lot and to many of the private hillside residences of Muir Beach is via Pacific Way. Pacific Way varies in width from its intersection with Highway One to the parking lot at the beach. For most of the road's length, there is sufficient room for two-way traffic, but not sufficient space for parking alongside the driving lanes. Illegal shoulder parking results in congestion and conflicts with emergency vehicle access to the beach. The existing road bridge across Redwood Creek is a bottleneck for vehicles, and exacerbates the traffic congestion and safety concerns. It is narrow, allowing only one-way traffic, with no separate space for pedestrians, bicycles, or horses. The bottleneck is experienced by all visitors who come to the site periodically, but is particularly acute for the residents who live with it throughout the seasons. The narrow bridge, in combination with the short sight distances on the winding road, lack of separation between moving vehicles and trail users, and presence of illegally parked vehicles, makes for an unsafe condition for all.

The parking lot itself can be very congested on heavy use days, due to the limitations of the internal circulation system. With only one common point of ingress and egress, and no secondary internal circulation loops, a single car waiting for a parking space can stop all traffic, with no possibility of getting around the stopped vehicle.

The parking lot is closed in the evenings, but visitors frequently arrive after closing and park at the Pacific Way entry, causing after-hours congestion directly in front of some of the residences. The noise of these visitors' evening activities is also typically disruptive to the residents.

8.1.3 Visitor Access: Trails

There is no connection between the southerly Coastal Trail and any of the other regional trails: the Diaz Ridge Trail, the Redwood Creek Trail, and northerly Coastal Trail. There is also no clearly marked crossing of Highway One providing a safe connection between the stable and the project site. Some visitors use Muir Beach as a trailhead destination, but more would use it with adequate and well-marked trail connections.

Hikers and equestrians can make a loop around the project site on a combination of roads and trails for an overall length of 0.8 miles. Hikers have a choice of another possible loop of 0.9 miles by utilizing the footbridge connection with the parking lot and Pacific Way for most of its length. The jointly used loop includes the levee road, Pacific Way between the road bridge and the Pelican Inn parking lot, the Green Gulch Access Road, and the Green Gulch Trail between the levee road and Green Gulch Farm. Both loops are well used by residents and are important parts of their regular activities at the site. The combination loop system of road and trail does not meet current ADA standards for an accessible route, either in terms of surface materials or separation from vehicular traffic. The southerly Coastal Trail connects with the loop at the southeastern edge of the site approximately 400 feet from the beach.

Equestrians make use of a paddock and riding ring on the project site near the intersection of Pacific Way and Highway One. Most horses in the area are stabled at the former dairy across Highway One from the project site. Additional pasture for the horses is provided in Field 7 of the Green Gulch Farm complex, on the project site.

Access to the beach is currently available through the dunes on a sandy trail extension of the Levee Road just south of its connection with Green Gulch Trail. Most visitors get to the beach from the parking lot by crossing the footbridge and then passing through the dunes. The trail at the edge of the parking lot is a utilitarian connector to the footbridge with some interpretive material, access to a picnic area, and access to restrooms. The distance from the end of the parking lot to the beach is approximately 500 feet.

8.1.4 Visitor Experience

The primary experience for visitors that is offered by Option A, the No Action Alternative, is a trip to the beach. The beach itself offers a sense of wildness and relief from the dense metropolis nearby. The setting seems natural, rural, and spacious to most visitors, particularly in contrast to the adjacent built-up urban areas. The perception of the setting in the recent past was that of an agricultural or pastoral scene with animals grazing on lowland meadows. This is different from the way it is perceived today, although some of that imagery remains. With the changes to the hydrologic regime, the landscape has been transforming to more of a marshy condition, and the experience of the place has been changing to more of a seemingly natural wildlife habitat. However, there is little understanding by most visitors of the degree to which this "natural" area is ecologically degraded, manipulated, or unsustainable. Although the general perception of a healthy natural area does not square with the reality of the existing condition, the experience of most visitors is that of being in a relatively untamed natural landscape.

The access system does little to connect the visitors to the entire natural setting, or to engage the visitor in a broader landscape experience than the beach alone. The visitor can see the transforming meadow from the Highway One approach to the site and get a sense of the overall setting. But once on Pacific Way, the landscape system becomes more confusing: the creek is perched at a high elevation near the hillside, the low spot in the road often floods, and exotic vegetation dominates the forest along the roadside. At the end of the road, the dense tree cover opens up as the visitor swings into a bare, windswept, and dusty parking lot that appears unconnected with any part of its natural or constructed setting. The view of the beach is compelling, but the parking lot provides no ecological point of reference. It seems like a no-man's land on the way to the beach, rather than an integral part of the destination, and it is an eyesore to both the hillside residents and the regional trail users. The walk to the beach includes a bridge crossing of Redwood Creek, and it is here that the visitor finally comes into contact with the central feature that has formed the upstream landscape. Upon closer inspection, however, it is clear that the creek is constrained artificially in this location. The trail then passes through the dunes (much trampled but partially recovering) on the way to the beach.

There is only limited potential to interpret the natural system of the project area since there is so little of it to see other than the beach, beach processes, and salmon runs. The archeological and cultural heritage of the site could be interpreted, but there are neither adequate facilities nor a sufficiently compelling setting at present for the interpretive program to be developed to best advantage.

The Levee Trail currently offers the greatest visitor contact with the emerging wetlands and quiet backwater habitats. But these are the most sensitive habitats on the site, and the human access system takes people directly through their center. While the experience along the Levee Road is a uniquely natural one under the No Action option, the human intrusion into and through the most sensitive habitat creates a significant conflict with the natural system.

8.2 Option B – Parking Lot at Beach

8.2.1 Visitor Access: Parking

Refer to Section 6.2.1 for a description of the parking under Option B. The new parking lot in Option B is designed to visually connect with the adjacent riparian woodlands, to satisfy the parking demand calculated by the CTMP, and to minimize conflicts with the natural creek flow. It would offer a significant improvement over Option A in terms of parking, circulation, and creek dynamics, although it would remove approximately 1.4 acres of existing riparian woodland. The provision of parking for up to 200 cars should significantly decrease the amount of illegal shoulder parking on heavy-use days, and thus relieve congestion on Pacific Way and improve safety.

8.2.2 Visitor Access: Traffic Circulation

Access to the public parking lot would be the same as in Option A, but the Pacific Way access route would be improved to accommodate two-way traffic from the Highway One intersection with a positive separation for trail users. The existing bridge across Redwood Creek would be removed and replaced with a wider and longer structure for two-way traffic plus a pedestrian walkway, thereby eliminating the most significant vehicular bottleneck and safety problem on the road. The road edge would be defined positively with an asphalt curb, timbers, or other measures to discourage shoulder parking and ease the resultant congestion.

Circulation within the parking lot would be improved by the provision of two points of ingress and egress, as compared with the single entry of Option A. The parking lot is also designed with a series of internal circulation loops to allow flexible movement throughout the lot and minimize the problems of blockage of a parking bay by a single vehicle.

Depending on the outcome of the CTMP process, Option B could provide a special drop-off facility for a shuttle service close to the beach. There is no shuttle drop-off in Option A. The shuttle bus could have a separate driveway serving the drop-off directly, thus minimizing the conflict with parking lot circulation. The shuttle, private visitor vehicles, and resident vehicles would share the entire entry road up to the separate entry drives. With the improvements to the roadway, the congestion should diminish.

8.2.3 Visitor Access: Trails

Although these regional trails lie beyond the project boundaries, Option B could support future connection of the project site and Muir Beach with the Diaz Ridge and Redwood Creek trails across Highway One to the Golden Gate Dairy.

This option would remove one leg of the existing loop trail system, the Levee Road, but would reestablish the loop with a continuous ADA-compliant off-road trail. This would be an improvement, since portions of the existing loop are on the existing roads and do not comply with ADA. In the case of the leg along Pacific Way, the proposed alignment for the trail is in the bed of the existing, artificial creek, which would be relocated. The new loop trail in this option would be approximately 0.9 miles long, the same as the longer loop in Option A. A new pedestrian bridge, proposed across Redwood Creek southeast of the parking lot, would complete the loop. This bridge would be made accessible for equestrians as well as hikers and bicycles.

Access to the beach would be retained through the dunes on the south side of the creek, as in Option A, with some small but important changes. The footbridge would be moved upstream to a less sensitive and constrictive location, and would also be extended to allow unimpeded flows in the channel. The picnic area would be located in a less sensitive relationship to the creek and connected directly with the trail. The trail itself between the end of the parking lot and the beach would be slightly longer than in Option A: roughly 600 feet instead of 500 feet.

The equestrian riding ring would be removed in this option. The paddock adjacent to Highway One would be retained. A portion of Field 7 of Green Gulch Farm would be retained as horse pasture.

Emergency access to the southern part of the site would be provided along the easterly portions of the loop trail. The portion to be used by emergency vehicles would be widened to 12 feet (as required for the vehicles) and engineered to withstand the heavy loads. The surface material, however, would be similar to the rest of the trail. The existing emergency staging area would remain, as in Option A.

8.2.4 Visitor Experience

Option B expands the range of visitor experiences offered at the project site beyond the beach to include the upstream creek restoration areas. The sense of wildness at the beach would be expanded to include a healthy, functioning natural stream corridor with its attendant woodlands and wetlands at the center of the community. The primary experience for the visitors in this option, however, would be the beach as in Option A. All visitors would arrive at the beach parking lot or shuttle drop-off, and proceed to the beach across a bridge and through the dunes, much like in Option A. However, the loop trail would also be available for those who wish to use it, and it is here that the range of natural experience for the visitors would be expanded.

The experience of arrival at the parking lot would be changed from that of Option A, for the lot would planted with trees and linked visually with the adjacent riparian woodlands. Visitors would arrive at a place defined by the surrounding landscape; they would feel as though they had entered the margins of the natural woodlands. Passage to the beach or to the trails would be from within this woodland landscape to an ecologically linked downstream landscape, not simply from a bare and dusty vehicle-storage area to a sandy beach.

The restored riparian zones offer new opportunities for interpretation and understanding of the heritage and processes of this place. An interpretive blind/overlook deck for the restored creek habitat is proposed at the southeastern edge of the wetlands, penetrating into the habitat a short way, to overlook the restored creek and its tributaries. Other interpretive displays are suggested near the parking lot trail to the beach and near the connection with the south Coastal Trail. The latter could be an appropriate location for interpretation of the history of human settlement patterns within this natural landscape. The Levee Road would be eliminated in this option, and human intrusion would be kept outside the most sensitive habitat areas. The intent is to encourage an increase in wildlife into the area and to enhance people's perception of this as a place of healthy nature, teeming with wildlife and co-existing with humans.

8.3 OPTION C – PARKING LOT AT BEACH & ALDER GROVE

8.3.1 Visitor Access: Parking

Refer to Section 6.3.1 for a description of the parking lots under Option C. The maximum number of parking spaces provided at the project area would be 200, the same as Option B and the equivalent of the CTMP's peak-season weekend demand. The difference in this option is that the parking at the beach would be intended to satisfy the levels of demand during most of the year, with the remote lot available for the additional demand on the busiest days. The remote lot would also be available for visitors desiring a more comprehensive natural experience, consisting of a walk to a coastal beach along its upstream riparian wetlands. The Alder Grove lot would be located approximately one-half mile from the beach, as compared to the 600-foot walk from the beach lot.

As with Option B, the lots are designed to visually connect with the adjacent riparian woodlands, to satisfy the parking demand calculated by the CTMP, and to minimize conflicts with the natural creek flow. This option would offer a significant improvement over Option A in terms of parking, circulation, and creek dynamics, although it would remove approximately 1.6 acres of existing riparian woodlands (0.9 acres at the beach and 0.7 acres at the Alder Grove). As with Option B, the provision of parking for up to 200 cars should significantly decrease the amount of illegal shoulder parking on heavy use days, and thus relieve congestion on Pacific Way and help to improve safety conditions. In order to educate visitors about the choice of lots, signs would have to be placed near the Highway One intersection with Pacific Way, directing visitors to the remote lot.

8.3.2 Visitor Access: Traffic Circulation

Option C would make the same modifications to Pacific Way, the road bridge, the separation of shuttle access drive from the parking drive, and the internal parking lot circulation as Option B. These changes should improve the traffic circulation system at least as well as Option B would do. The smaller size of the parking lot could even result in less traffic on Pacific Way, but this would require diligent monitoring of the parking lot capacity, timely signage at the intersection (informing visitors that the lot is full), and diligent enforcement of no-parking regulations.

One additional proposal included in this option, intended to help alleviate traffic circulation conflicts between visitors and residents on Pacific Way, is the creation of a new parking lot driveway 500 feet north of the existing entry. Just beyond this public entry drive would be a sign and gate, limiting further access on Pacific Way to residents and shuttles only. This is intended to help control public access into and parking within the residential neighborhood, and to move the after-hours nighttime activities at the closed gate away from the residents. It would also allow a longer queue for vehicles entering and exiting the parking lot.

Some visitors to the beach, who park in the remote lot, may use the drop-off before parking and after returning from the beach. This would increase the volume of traffic on Pacific Way beyond that from the parking lot alone. Although not all remote-parking visitors would want to use the drop-off, some would. In any case, it is expected that the volume of traffic on Pacific Way under this option would be less than or equal to the existing levels.

As with Option B, the reconstruction of Pacific Way would include a treatment of the edge of the road in a way that positively discourages roadside parking. Raised curbs, timbers, or other measures would also clearly separate the roadside trail from the roadway.

The provision of a remote lot in the Alder Grove would change the traffic circulation patterns on Highway One. A new entrance for 50 cars on the highway would require additional turning maneuvers, particularly a new left turn off of Highway One. Good visibility would be required, as would adequate turning lanes.

The provision of a shuttle drop-off would be similar to Option B: a significant improvement over the existing conditions.

8.3.3 Visitor Access: Trails

The same loop trail system and regional trail connections are proposed for Option C as in Option B, with only minor variations. In Option C, the trail leg along Pacific Way would not follow the former creek bed as in Option B, but would instead run alongside but separate from the roadway. An interpretive blind/overlook boardwalk into the marsh would be included as in Option B, but in this case it would be aligned to overlook the small excavated lagoon on the east side of Redwood Creek, near the confluence with Green Gulch Creek. A final variation would be the pathway from the beach parking lot to the footbridge. In Option C, the path would pass through a small area designated for dune evolution before crossing the creek and passing through the dunes, rather than merely acting as an edge to the parking lot, as called for in Option B.

One additional trail is proposed between the remote Alder Grove parking lot and the Pacific Way loop trail segment. This trail would pick up visitors from the parking lot and carry them through the riparian forest, staying approximately 100 feet from the creek bank. Provision is also made for a future connection to the Redwood Creek Trail and possibly to the northern portion of the Coastal Trail to the northwest along Highway One, if deemed feasible. The distance to the beach by this trail from the remote parking lot would be approximately one-half mile, as in Option B.

Treatment of the riding ring, paddock, horse pastures, and emergency access routes in this option would be the same as in Option B.

8.3.4 Visitor Experience

Option C would offer the same expanded range of experiences as Option B beyond the beach, but with an even greater variety in the upstream creek and wetland restoration areas. Option C would also offer these experiences as a primary part of the access system to the beach, not as a secondary activity as in Option B. The experience of the longer trail from the parking lot to the beach (approximately 0.7 miles) would include a rich ecological sequence, depending on the restoration alternative chosen. The trail from the remote parking lot would add approximately 550 more feet of trails than those in Option B, and possibly even more if a connection to the Redwood Creek Trail along Highway One could be safely made.

The experience of arrival at the parking lots would be similar as in Option B, as the parking lots would be densely planted with riparian trees and have easy trail access. The interpretive opportunities would be similar to those in Option B, with the addition of the natural features within the riparian forest itself. In this case, an interpretive blind/overlook is also proposed for viewing the small lagoon/wetland instead of the creek channel in Option B.

8.4 OPTION D – PARKING LOT AT ALDER GROVE

8.4.1 Visitor Access: Parking

Section 6.4.1 describes the potential configurations for parking under Option D. The total number of vehicles parked at the site under Option D would be 132, 43 less than the capacity of Option A. The parking under this option would be 12 more than the existing off-season weekend peak demand, 18 less than the existing shoulder-season demand, and 68 less than the existing peak-season weekend demand. The proposed lot at the Alder Grove under this option is the largest feasible without significant encroachment into the flood zone. Since the parking available on-site under this option would not meet either the existing peak-season or shoulder-season demand, the parking deficit must be accommodated elsewhere with routine and dependable shuttle service, as recommended in the CTMP. Without the support of an off-site lot, a shuttle, and diligent visitor education, it is expected that there would be increased pressure for shoulder parking along Highway One and Pacific Way under this option.

8.4.2 Visitor Access: Traffic Circulation

As with Options B and C, Option D proposes the same modifications to Pacific Way and the Pacific Way road bridge to safely accommodate two way traffic and to separate trail users from the roadway. The reduction to the number of parking spaces offered at the beach would likely have the effect of reducing the volume of traffic on Pacific Way. However, the potential reduction may be partially offset by visitors who would park in the remote lot and use the drop-off before and after their visit to the beach. Signage would be required at the intersection of Pacific Way and Highway One, to direct visitors to the remote lot.

Access to the remote 118-vehicle lot in the Alder Grove would involve a new driveway along Highway One. A single driveway entry is proposed, in order to limit the number of ingress and egress points along the highway. As with Option C, it is likely that new turning lanes would be required along the highway for the parking lot.

In this option, more so than Options B or C, the traffic circulation impacts would likely include continued impacts along Pacific Way, plus significant additional impacts on Highway One at the new driveway entrance. The beach would continue to be the primary destination for most visitors who would want to use the drop-off, and the remote parking would be the primary vehicular storage area. The likely result would be that visitors would drive to both destinations, spreading the impact out to a larger area by this "double-drive".

The total number of cars parked at the site would likely result in lower volume of traffic at the site and fewer circulation conflicts, but only if the related off-site parking and shuttle improvements recommended in the CTMP were implemented and a concerted public education program were instituted. The potential decrease in conflicts with residents and improved safety for trail users would also be tied to the simultaneous implementation of the off-site CTMP recommendations. If the off-site improvements and programs were not implemented, traffic volume and circulation conflicts might be greater under Option D than under Options A, B, or C. Not only would the available parking decrease, but it would also be removed from the primary destination for most visitors.

8.4.3 Visitor Access: Trails

Option D proposes essentially the same trail system as proposed in Option C, with one significant difference. Instead of a footbridge southeast of the parking area across the creek to the dunes, this option would include a boardwalk directly between the drop-off and the beach across the tidal lagoon in the location of a former boardwalk. Visitors arriving at the drop-off would be able to get directly to the beach over a distance of approximately 350 feet. The connection to the loop trail and the rest of the trail system at the site would be less direct than in Options A, B, or C.

The boardwalk itself is proposed in a location that may be affected by storm surges and beach building/erosion processes. Its construction would need to take into account both the strength of the forces to which it would be subject and the need to provide an accessible ramped pathway onto a surface that changes elevation seasonally.

The internal loop trail would be extended through the dunes and a portion of the sandy beach to tie into the boardwalk. While the sandy surface of the dunes and beach may be accessible to hikers and horses, it will be more difficult for cyclists and inaccessible for people with mobility limitations without special surfacing. Special paving surfaces in areas with active dunes and beach processes are very difficult to maintain and keep free of drifting sand.

One other minor variation to the Option C trail system is the provision for an extended boardwalk across one portion of the restored wetland. In Options B and C, access into the wetland restoration area is proposed as a single point for interpretive purposes. In this case, a small zone of the restoration area is proposed for development in conjunction with a boardwalk of approximately 400-foot length with an integral overlook facility. This accessible boardwalk would be available for pedestrians only, serving as a cut-off trail for people headed toward the beach via the Green Gulch Road and Trail. It would also likely decrease the number of people entering Green Gulch Farm via the Green Gulch Road.

8.4.4 Visitor Experience

Option D would offer a fundamentally different beach access experience for most of the visitors to the site, as compared with Options A and B. It would be similar to that offered in Option C, but in this case, it would be a part of most visitors' experiences, since most of the parking would be at the remote Alder Grove lot. The trip to the beach would include a journey through the upstream landscape and restored natural system, not just a quick hop over the creek to the sandy shore. In this extended journey, the visitors would be made aware of the ecological and physical context for this small coastal lagoon complex. It would also be an experience that emphasizes a trail as the primary access route, not a vehicle-filled road.

The experience of arrival at the parking lot or drop-off would be similar to Options B and C, in that the parking facilities would be densely planted and have easy trail access. In addition, the interpretive opportunities along the trail would be the same as in Option C and similar to Option B, depending upon which restoration alternative is implemented. The primary difference in interpretive resources for this option is the elimination of the footbridge across the creek, which would release the creek from the constructed constraints of each of the other options.

9. COMPARISON WITH PROJECT OBJECTIVES

Each ecological restoration alternative was evaluated against the project objectives identified in Section 3.3. Alternatives were rated for their relative ability to meet the objective, using the qualitative and quantitative indicators for guidance. Where the ability to meet the objective is expected to change significantly as the site evolves within the planning horizon, ratings were provided at both Year 5 and Year 50.

We then evaluated how public access options, when combined with the alternatives, would meet relevant objectives relative to resident and visitor experience. The comparison matrices for restoration alternatives and public access options are summarized in Table 9-1 and Table 9-2 respectively, followed by a brief discussion of each objective.

9.1 COMPARISON OF RESTORATION ALTERNATIVES & RELEVANT OBJECTIVES

Table 9-1. Comparison Restoration Alternatives and Relevant Objectives

OBJECTIVES	Relative Ability to Meet Objective			
	Alternative 1 No Action	**Alternative 2 Creek Restoration**	**Alternative 3 Creek & Small Lagoon Restoration**	**Alternative 4 Large Lagoon Restoration**
GEOMORPHIC				
1. Remove constraints to natural geomorphic processes, such as sediment transport, channel migration, channel-floodplain interaction, and seasonal and long-term beach change.	○	●●	●●	●●
2. Rely on geomorphic processes to maintain and support the restoration.	○	●●	●●	●●
3. Accommodate future watershed sediment delivery.	○	●●	●●	●●
4. Restore and accommodate natural beach processes.	○	●●	●●	●●
5. Accommodate physical disturbance (i.e. extreme hydrologic event, storm surge, sediment pulse, fires, earthquakes, etc.).	○	●	●	●●
6. Restore physical complexity of creek channel.	●	●	●●●	●

OBJECTIVES	Relative Ability to Meet Objective			
	Alternative 1 No Action	**Alternative 2 Creek Restoration**	**Alternative 3 Creek & Small Lagoon Restoration**	**Alternative 4 Large Lagoon Restoration**
ECOLOGICAL				
7. Improve coho salmon and steelhead winter/spring rearing habitat. Year 5 Year 50	 ○ ○	 ● ●	 ●●● ●●	 ● ●●
8. Provide a migration corridor for steelhead and coho salmon.	●	●●	●●	●●
9. Maintain or improve breeding and rearing habitat for red-legged frog (*Rana aurora draytonii)*. Year 5 Year 50	 ● ●	 ●● ●●	 ●● ●●●	 ● ●●
10. Re-establish natural lateral and longitudinal connectivity among channel, floodplain, riparian, and upland habitats.	○	●●●	●●	●●
11. Enhance bird diversity. Year 5 Year 50	 ○ ●	 ○ ●●	 ●● ●●●	 ● ●●●
12. Provide quality (e.g., high reproductive success) habitat for riparian/wetland-associated birds (particularly neotropical migrants). Year 5 Year 50	 ○ ●	 ○ ●●●	 ● ●●	 ● ●
13. Enhance native dune processes and increase diversity of native dune communities.	○	●●	●●	●●
14. Enhance native wetland and riparian plant assemblages.	●	●	●●●	●●
15. Provide a diversity of estuarine habitats.	●	●	●●	●●●
HYDRAULIC (Related to Resident Access/Experience)				
27. Provide safe year-round access for Muir Beach residents.	○	●●	●●	●●
28. Avoid adverse impacts to upstream properties that could result from channel adjustment.	○	●●	●●	●●
29. Do not increase flood hazards to private property.	○	●	●	●●

OBJECTIVES	Relative Ability to Meet Objective			
	Alternative 1 No Action	Alternative 2 Creek Restoration	Alternative 3 Creek & Small Lagoon Restoration	Alternative 4 Large Lagoon Restoration
CONSTRUCTABILITY				
30. Provide a restoration approach that can be implemented in a feasible manner.	●	●●●	●●	●●
31. Develop a restoration plan that can be implemented in a cost effective manner.	●●	●●●	●●	●
CULTURAL RESOURCES				
32. Preserve, undisturbed, indigenous archeological sites in the project area.	●●	●	●	●

Table Key:

○ Alternative does not meet the objective.

● to ●●● The relative degree to which the alternative meets the objective, with ●●● being the highest rating.

1. Remove constraints to natural geomorphic processes.

Alternatives 2 to 4 remove the existing constraints on key geomorphic processes, including sediment transport, channel migration and channel-floodplain interaction. Five key indicators were identified for this objective:

a. Degree that human structures (e.g., bridges, culverts, trails, parking lot, etc.) disrupt sediment transport, limit channel migration, and contribute to flooding.
Under the No Action Alternative, Pacific Way Bridge, levee road, and the Muir Beach parking lot will continue to disrupt sediment transport in Redwood Creek and lead to diminished channel capacity resulting in flooding problems on Pacific Way. The levee road also acts as a barrier to channel migration, keeping Redwood Creek on the far western edge of the valley above its equilibrium floodplain elevation. Under Alternatives 2 to 4, Pacific Way Bridge and the levee road are removed, and the parking lot is modified to minimize effects on geomorphic processes. Removal of the levee road and relocation of the channel to the center of the valley under Alternatives 2 to 4 will allow channel migration and channel-floodplain interaction during high flow events. Pacific Way Bridge will be replaced with a raised causeway, minimizing disruptions to flow, sediment transport, and channel migration. The parking lot at Muir Beach will pulled back at least 90 feet, reducing constraints on flow and sediment transport.

b. Width of corridor available for lateral channel migration.
Alternatives 2 to 4 provide similar area for lateral channel migration, about 200 ft upstream of Pacific Way and 300 ft downstream of Pacific Way. Under the No Action Alternative,

channel migration is not possible, except during a complete channel avulsion during a major flood event.

c. Areal extent of connected 1.5- to 2-year floodplain.
Alternatives 2 to 4 increase the hydraulic connectivity of the channel and floodplain over existing conditions. While flows typically escape the channel during 2-year events or less under Alternative 1, the levee road and Pacific Way obstruct return flows to the channel and prohibit true channel-floodplain connectivity. Alternative 2 provides the greatest aerial extent of connected 1.5- to 2-year floodplain, while Alternatives 3 and 4 provide less area due to the lagoons occupying portions of the floodplain area.

d. Areal extent of connected 50-year floodplain.
Under the No Action Alternative, portions of Pacific Way and Green Gulch pasture are likely flooded during 1.5 to 2-year flows, but these flooded areas do not provide hydraulically connected floodplain habitat. Under Alternatives 2 to 4, the restored Redwood Creek channel has been sized to carry the 1.5 to 2-year flows at bankfull. For Alternatives 2 to 4, channel relocation and removal of the levee road will improve channel-floodplain connectivity. Most of the project site is inundated during a 50-year flood event under any alternative; therefore, all four alternatives have roughly the same areal extent of connected 50-year floodplain.

e. Width of active beach.
Under Alternatives 2 to 4, the lower portion of Redwood Creek is moved seaward about 100 feet. However, by aligning the channel in the non-vegetated, easily mobilized sand of the back beach, the channel will be able to migrate with seasonal and long-term changes in beach morphology.

2. Rely on geomorphic processes to maintain and support the restoration.

Alternatives 2 to 4 are anticipated to be self-sustaining under the existing geomorphic conditions at the site without management intervention. In contrast, the No Action will require continued maintenance of the Redwood Creek channel to maintain the existing channel location and reduce flooding of Pacific Way. We estimate that on average about 500 yd^3/yr of material will need to be removed from the channel downstream of Pacific Way Bridge.

3. Accommodate future watershed sediment delivery.

Alternatives 2 to 4 improve the capacity of the project site to accommodate future watershed sediment delivery relative to No Action. We estimate that Alternative 2 would increase sediment transport to the ocean by a factor of two and provide significantly more floodplain area for sediment deposition. Under Alternative 3, about the same amount of sediment would be trapped on the project site as under No Action, but the sediment deposition would be distributed primarily on the floodplain and in the small lagoons such that channel capacity would be maintained. Under Alternative 4, about twice the volume of sediment would be trapped in the Large Lagoon relative to No Action, but the lagoon would have a large capacity to accommodate sediment deposition.

4. Restore natural beach processes.

Under the No Action Alternative, beach processes are not significantly altered from natural conditions. However, the current location of the pilot channel in the Willow/Alder grove has reduced back beach scour and allowed sediment to accumulate and raise the back beach elevation. Alternatives 2 to 4 restore the historical alignment along the open sand of the back beach and should reduce the elevation of the back beach. Five key indicators were identified for this objective:

a. <u>Capacity of the creek to transport coarse sediment to replenish the beach.</u>
Under the No Action Alternative, most of the coarse bedload and suspended sediment would be trapped in the creek channel upstream and downstream of Pacific Way Bridge. Alternative 2 is expected to increase the amount of coarse sediment delivered to the beach by a factor of 2. Alternative 3 would trap about the same quantity of coarse sediment in the small lagoons as under No Action. Alternative 4 would trap about twice the amount of coarse sediment as under No Action. However, the dependence of Muir Beach on sand supplies from Redwood Creek is low relative to supplies from longshore transport. Previous studies in nearby Bolinas Bay and in the Santa Cruz littoral cell (Golden Gate to Monterey Bay) have found annual littoral transport volumes on the order of 150,000 – 250,000 yd3/yr (Best and Griggs 1991, IEC 1968). Annual sand discharge from Redwood is 2 orders of magnitude less than sand supplies by longshore transport; therefore, the changes to sediment discharge to the ocean anticipated from restoration actions are small relative to littoral sand supplies. No significant changes to the beach berm or nearshore bar dynamics are anticipated due to changes in sediment discharge.

b. <u>Areal extent of re-created active dune fields.</u>
The areal extent of restored dunes is the same at Year 0 for all alternatives (0.1 acre), but in Year 50 the areal extent of active dunes is increased to 2.6 acres under Alternatives 2 to 4.

c. <u>Extent that the design impacts littoral transport, local littoral sediment budget, and nearshore habitat.</u>
Alternatives 2 to 4 do not have an impact on littoral transport or nearshore habitat. Alternative 2 would discharge more sediment to the beach and nearshore zone than under No Action, but most of this additional sediment would be coarse material that would increase sediment supply to the beach and not adversely impact nearshore habitat. Under Alternative 3, there would be no significant change in the amount of sediment discharged to the littoral zone. Under Alternative 4, there would be a reduction in coarse sediment supplied to the beach, but it is not anticipated to significantly impact beach morphology for reasons described in 4a above.

d. Extent that the design accommodates beach retreat due to future sea level rise over the 50 year planning horizon.
In the next 50 years, sea level rise is anticipated to cause about 20 to 30 feet of beach retreat. The net width of Muir Beach should stay about the same if sediment supplies are not significantly altered, and the beach will migrate landward 20 to 30 feet. Under all alternatives, there is adequate space on the project site seaward of the parking lot to accommodate this beach retreat. The primary barrier to future, long-term beach retreat is the beach parking lot, which remains in the same location under all alternatives, unless the parking lot is relocated to the Alder Grove (under Public Access Option D).

e. Extent that the design accommodates seasonal beach changes and infrequent extreme storm events.
Under all alternatives, there is adequate space on the project site to accommodate seasonal beach changes and occasional storm surge. During large storm events, wave overwash reaches the seaward edge of the parking lot, which remains in the same location under all alternatives, unless the parking lot is relocated to the Alder Grove (under Public Access Option D).

5. Accommodate physical disturbance.

Alternatives 2 to 4 are more resilient than the No Action Alternative to major fluvial disturbances, such as larges floods, sediment pulses, and woody debris, due to their larger channel capacity and floodplain width. Given the larger areas available for water and sediment storage, Alternatives 3 and 4 could accommodate larger flood and sediment deposition events. Alternatives 2 to 4 would also be more resilient to large storm surge or wave overwash events than under the No Action due to the relocation of the lower channel on the back beach. Sand would tend to be deposited in the back beach channel during large overwash events, but the channel would be easily reestablished by channel scour during subsequent high discharge events. Under the No Action Alternative over the 50-year planning horizon, windblown sand is expected to be deposited in the existing pilot channel and would be less likely to scour due to the limited conveyance of the existing channel.

6. Restore physical complexity of creek channel.

Alternatives 2 to 4 would create more physical complexity in the creek channel than the No Action Alternative, as described for the following key indicators:

a. Ability to accommodate sudden, large-scale shifts in channel location and width of corridor available for lateral migration.
Alternatives 2 to 4 would restore 200 to 300 ft of active floodplain to accommodate sudden, large-scale shifts in channel location or migration. Under the No Action Alternative, the levee road holds the channel in place downstream of Pacific Way, preventing channel migration. Upstream of Pacific Way, channel avulsion is possible under the No Action

Alternative, but the new channel may be composed of several distributary branches until a dominant channel evolves. Over this evolutionary period, a main channel may not be well defined, potentially preventing upstream migration of anadromous fish species.

b. Potential for large woody debris recruitment.
Although perhaps less than No Action, Alternatives 2 to 4 have potential to recruit woody debris for channel complexity, particularly if the restored channel is constructed with limited impact on existing riparian woodland habitat. Alternative 4 offers less potential for recruitment of woody debris than Alternatives 2 or 3 given the smaller length of channel in this design.

c. Channel sinuosity or length of connected channels.
Alternatives 2 and 3 would provide greater length of connected channel habitat and greater channel sinuosity than under the No Action Alternative. Alternative 4 would provide less connected channel habitat than the No Action Alternative, but the channel would be connected to the large open-water lagoon and surrounding emergent wetland.

7. Improve coho salmon and steelhead winter/spring rearing habitat.

Coho salmon and steelhead winter rearing habitat are anticipated to be improved under all three restoration alternatives, compared to the No Action Alternative. Under Alternative 3, the creation of the two small backwater lagoons with low velocity habitat would provide the largest improvement in off-channel winter rearing habitat of any alternative, although this is anticipated to be temporary (by Year 50, the small lagoon areas are expected to fill in, resulting in a backwater condition similar to that proposed under Alternative 2). Alternative 4 would provide the smallest improvement in winter rearing because the large lagoon does not provide refuge from winter high flows, compared to the backwater areas of Alternatives 2 and 3. Water quality, specifically temperature and dissolved oxygen, may temper some of the benefits of increased rearing habitat under all restoration alternatives in the short-term, until riparian vegetation has matured and can provide adequate shading. For Alternatives 2 and 3, preservation of existing vegetation on the west bank of the existing borrow ditch channel, to the extent possible, would improve short-term water quality.

8. Provide a migration corridor for steelhead and coho salmon.

The characteristics of the reconstructed channel proposed under all the restoration alternatives should improve rearing and fish passage conditions for migratory coho salmon and steelhead. The newly constructed channels would allow improved geomorphic function, including bank scour and channel migration that would improve recruitment of large woody debris and also improve habitat conditions for salmonids, although these benefits would only be in the long-term.

9. Maintain or improve breeding and rearing habitat for California red-legged frog.

Under the No Action Alternative, existing breeding and rearing habitat for California red-legged frog would be maintained. Currently, approximately 1 acre of existing habitat is known to be occupied by red-legged frogs in the Green Gulch Pasture (Fellers and Guscio 2003).

Under Alternatives 2 to 4, the ecological functioning of available wetland habitat and its suitability for red-legged frog breeding and rearing would be improved. The new wetland areas (e.g., the small wetland/pond complex proposed under Alternative 2 and the larger complexes under Alternative 3 and 4) would be connected to the creek channels and higher elevation riparian areas than existing wetlands under the No Action Alternative. Although Alternative 2 would initially provide a smaller wetland area (0.9 acres) than the No Action (1 acre) and Alternatives 3 and 4 (roughly 3 to 4 acres), this wetland area would presumably have greater habitat value for red-legged frogs because it would be less susceptible to salinity, predatory fish and water level fluctuations.

Alternatives 3 and 4 would provide approximately 2.7 and 4 acres, respectively of emergent wetlands at the margins of the lagoon(s). The margin habitat would provide a gradient from wetland species to surrounding riparian areas, improving the function of wetland habitats in terms of connectivity and dispersal compared to the No Action Alternative. Alternative 3 provides slightly higher ratio of margin habitat area to water surface areas, which will enhance this transition zone and also reduce the tendency of the small lagoons to become brackish throughout when compared to the large lagoon Alternative 4.

The deeper open water areas in both Alternatives 3 and 4 may be important for adult predator avoidance, but may also provide habitat for fish that prey on larval frogs (e.g., bass, sunfish, and mosquitofish [USFWS 1996]), thus reducing the potential for reproductive success.

Over time, Alternative 3 will maintain the most amount of functional wetland habitat (6 acres, compared to the approximately 1, 0.5, and 4 acres for the No Action, Alternatives 2 and 4, respectively) with benefits to red-legged frogs increasing as the open water lagoon habitat gradually fills and reduces the threat of predatory fish. Under Alternative 4, salinity and predatory fish would continue to be constraints on red-legged frog breeding and rearing habitat suitability through Year 50.

10. Re-establish natural lateral and longitudinal connectivity among channel, floodplain, riparian, and upland habitats.

Although each of the alternatives is anticipated to re-establish more natural lateral and longitudinal connectivity among habitat types, site evolution may require several decades to achieve this objective. In general, the creek restoration under Alternative 2 provides the most rapid attainment of these objectives, with the small and large lagoons requiring longer time periods for the establishment of vegetation. Under all access options, however, the site remains bordered on all sides by roads and trails.

11. Enhance bird diversity.

Due to the improvement of physical processes at the site, the diversity, complexity, and connectivity of habitat types at the project site is expected to increase under all alternatives compared to the No Action Alternative. Overall bird diversity is thus anticipated to increase under all alternatives, and to be maintained over time to varying degrees because of the diversity of habitat types and vegetation structure under all alternatives compared to the No Action Alternative. See the discussion for Objective 12 below for further details.

12. Provide quality (e.g., high reproductive success) habitat for riparian/wetland-associated birds (particularly neotropical migrants).

Due to the increase in the diversity, extent, and connectivity of habitat types at the project site, overall bird diversity and available habitat for riparian/wetland-associated birds is anticipated to increase under all alternatives compared to the No Action Alternative. Under all of the alternatives, the total extent of wetland habitat would be reduced compared to the No Action Alternative (Table 7-3); however, the newly created wetlands would likely be more self-sustaining (supported by natural hydrologic and geomorphic processes) and provide higher quality, functional habitat for various focal species. Alternative 3 would maintain the greatest diversity of open water, wetland, and riparian habitat types over time, and the largest acreage of wetland habitat over time among the three restoration alternatives. Alternative 2 would maintain the most acreage of riparian vegetation that could be used by riparian-dependent birds such as neotropical migrants, but would provide only a small increase in the diversity of estuarine habitats compared to the No Action Alternative. Creation of the large lagoon under Alternative 4 would result in the most significant loss of existing riparian vegetation, but should still provide adequate conditions for new riparian vegetation to establish and mature over time, and would, along with Alternative 3, create a higher diversity of estuarine habitats compared to Alternatives 1 and 2.

13. Enhance native dune processes and increase diversity of native dune communities.

Each of the three restoration alternatives proposes the same improvements to native dune communities by enhancing dune processes between the existing parking lot and tidal lagoon. A combination of slight water table decline after the new creek channel is cut to the tidal lagoon and development of dunes as prevailing winds bring in sand will drive the process. Removal of rubble and the old retaining wall from the tavern should also enhance the area. Some active management of the area is likely to be necessary to continue to control non-native invasive plant species and restrict access by humans and dogs.

14. Enhance native wetland and riparian plant assemblages.

Although all of the alternatives would provide significantly less area of wetland habitat compared to the No Action Alternative (Table 7-3), Alternative 3 provides the most wetland that would be sustained over time through natural infilling of the two small backwater lagoons. As with Alternative 2, there would be a small initial loss of existing riparian habitat just downstream of Pacific Way to accommodate the new

Redwood Creek channel, and eventually a complete loss of the brackish marsh area between the parking lot and tidal lagoon by Year 50 to make room for additional dune evolution. Compared to the No Action Alternative, by Year 5 it is anticipated that there would be an increase in newly recruited (and/or planted) riparian vegetation.

15. Provide a diversity of estuarine habitats.

The restored brackish lagoon created under Alternative 4 would enhance the existing diversity of estuarine habitats. The small lagoons under Alternative 3 would increase diversity to a lesser degree, while Alternative 2 would provide the same mix of estuarine habitats that currently exists.

16. – 26. See Section 9.2 for a discussion of resident and visitor experience objectives.

27. Provide safe year-round access for Muir Beach residents.

Alternatives 2 to 4 reduce flood water levels on Pacific Way and Lagoon Way by increasing channel conveyance capacity above No Action and replacing the existing Pacific Way Bridge with a raised causeway with minimal impacts on flows in Q-50 events or smaller. Alternatives 3 and 4 reduce flood levels below Alternative 1 and 2 by providing greater storage capacity in the restored lagoons. In addition, the new bridge under Alternatives 2 to 4 should provide safer year-round access along Pacific Way for Muir Beach residents.

28. Avoid adverse impacts to upstream properties that could result from channel adjustment.

By relocating the restored channel in the middle of the project site within a small, vegetated berm, Alternatives 2 to 4 have lower potential than No Action for bank erosion at upstream properties resulting from channel migration. There is at least a 50-foot buffer from the restored channel to the nearest property line (Pelican Inn). Similarly, the restored channel slope should be relatively stable and more subject to deposition than erosion (Figures 15 and 16). Therefore, the restored channel poses lower risk to upstream properties from channel incision.

29. Do not increase flood hazards to private property.

Alternatives 2 to 4 reduce flood water levels and move the high velocity flows to the center of the valley, further away from existing structures than under No Action, with exception of the Pelican Inn. Alternative 4, followed by Alternative 3, provides the greatest reduction in water surface elevations during large storm events (Q50) within roughly 300 feet upstream of Pacific Way. Further upstream, water surface elevations for the 50-year event remain relatively unchanged compared to No Action. For these reasons, Alternative 4 provides the highest assurance that flood hazards would not be increased, followed in order by Alternatives 3, 2 and 1.

30. Provide a restoration approach that can be implemented in a feasible manner.

One of the limiting factors for implementation feasibility may be the ability to provide advance mitigation for special status species, especially the California red-legged frog habitat. Lowering of the groundwater table resulting from channel modifications would temporarily disrupt current favorable habitat conditions for red-legged frog in Green Gulch pasture until lowered wetland areas could be excavated. Another important consideration for feasibility is the degree to which coho and steelhead populations are impacted during construction due to fish relocation and other activities. A third factor is the extent and duration of construction impacts the Muir Beach community. For all three factors, feasibility becomes more challenging as the size of the excavation in Green Gulch pasture increases.

Implementation of Alternative 2 would leave the greatest portion of Green Gulch pasture undisturbed, including portions of the unnamed tributary channel, which appears to have high red-legged frog habitat value. Under alternatives 3 and 4, excavation of the lagoon areas would disturb large areas of Green Gulch pasture, which reduces the opportunities to create pond features in this area that could provide advanced mitigation for California red-legged frog.

All three restoration alternatives require extensive fish relocation efforts once flows are diverted from the existing channel to the new channel/lagoon systems. As described in Section 7.3.2, excavation of the large lagoon for Alternative 4 would be the most challenging in terms of minimizing impacts to fish populations. It should be note that channel dredging under the No Action Alternative would also require fish relocation and could have additional impacts to fish habitat quality (e.g. increased turbidity).

Considering that off-hauling 1,000 cubic yards of soil would require roughly 80 truck trips in each direction, any amount of soil disposal required by the project would create noise and traffic impacts on local roads and for the local community. Therefore Alternative 2, which has the least amount of offsite soil disposal (12,000 cubic yards), is considered to be the most feasible, and Alternative 4 (175,000 cubic yards) is considered to be the least feasible.

For the No Action Alternative, the construction feasibility of ongoing maintenance activities also needs to be considered, including difficulty in obtaining permits and providing mitigation. Assuming that dredging would require disposal an average of 500 cy/year, a total of 25,000 cubic yards would need to be disposed offsite in the 50-year planning horizon. Using soil disposal volume as the sole indicator, No Action Alternative is considered less feasible than Alternative 2 and somewhat more feasible than Alternative 3 (105,000 cubic yards of disposal) and Alternative 4.

31. Develop a restoration plan that can be implemented in a cost effective manner.

The two of the largest cost items for implementation of the alternatives would be earthwork and the new Pacific Way bridge. Since each alternative requires installation of a new bridge, the earthwork volumes were used as the primary indicator for relative cost evaluation. As described in Section 7.3.1, the estimated soil volumes requiring offsite disposal increase significantly between Alternatives 2 (12,000 cubic yards and Alternatives 1 (25,000 cubic yards[2]), 3 (105,000 cubic yards), and 4 (175,000 cubic yards). Although there are potential opportunities for some soil disposal within the watershed (Section 7.3.3), the total potential capacity is less than 100,000 cubic yards, requiring long-distance trucking and disposal for at least a portion of excavated material from Alternatives 3 and 4. Greater excavation and offsite disposal volumes, coupled with scheduling and other permitting constraints, increases the likelihood that implementation would be phased over more than one construction season, also increasing costs. For these reasons, Alternative 2 is considered the most cost effective, followed by Alternative 1, 3 and 4.

32. Preserve, undisturbed, indigenous archeological sites in the project area.

Based on available information, it appears that all the alternatives can be implemented in a manner that preserves the three identified archeological sites. The three sites are located 1) in the vicinity of Pelican Inn, 2) near the alluvial fan east of the footbridge, and 3) by the historical beach tavern location (see Section 4.5.2 of Part I). In general, because these sites were located at the fringe of the historic Big Lagoon, they are not in direct conflict with proposed restoration activities, but need to be carefully considered during the detailed design. For the three restoration alternatives, the limits of excavation for the new wetlands and lagoon areas need to be carefully delineated to not disturb the archaeological site located in the alluvial fan, in the southeast portion of Green Gulch pasture. In addition, the north abutment of the new bridge cannot not conflict with the Pelican Inn site. (This archaeological site requires further characterization to evaluate potential conflicts.) Finally, debris removal at the site of the historic tavern (south of the parking lot) should avoid the archaeological site. Because all of the alternatives require some disturbance in the vicinity of one or more sites, they each have more potential for disturbance than the No Action Alternative, although impacts at all sites except the Pelican Inn site could likely be avoided.

9.2 COMPARISON OF PUBLIC ACCESS OPTIONS & RELEVANT OBJECTIVES

The four public access options were evaluated for their ability to meet the objectives related to visitor and resident experience (Table 9-2). The basis for rating each objective is described below.

Table 9-2. Comparison of Public Access Options to Objectives

OBJECTIVE	Relative Ability to Meet Objective			
	Option A No Action	**Option B Beach Parking Lot**	**Option C Beach & Alder Grove Parking Lot**	**Option D Alder Grove Parking Lot**
VISITOR AND RESIDENT ACCESS/EXPERIENCE				
16. Engage visitors in the natural ecosystem and cultural heritage of the site.	○	●	●●●	●●

2 Over 50 years if maintenance dredging.

OBJECTIVE	Relative Ability to Meet Objective			
	Option A No Action	**Option B** Beach Parking Lot	**Option C** Beach & Alder Grove Parking Lot	**Option D** Alder Grove Parking Lot
17. Incorporate a broad spectrum of appropriate visitor experiences compatible with resources of the site.	○	●	●●	●●
18. Provide convenient access to public use facilities for people of all ages and abilities.	●	●●	●●●	●
19. Provide safe pedestrian access from parking/drop-off areas to public use destinations.	●●	●●	●●	●●
20. Provide safe and continuous linkages between currently disconnected trails for all user groups.	○	●	●	●
21. Provide safe vehicular access to the visitor resources.	●	●●	●	●
22. Minimize access conflicts between public visitors and residential users.	●	●	●●	●
23. Minimize land use conflicts between visitor access and adjacent uses.	○	○	●	○
24. Minimize conflicts between access and use of facilities and the natural function of the ecosystem.	●	●●●	●●	●●
25. Provide emergency access through site.	●	●	●	●
26. Reduce noise and aesthetic/visual distraction of parking and maintain "rustic character."	○	●●	●●	●●●
CULTURAL RESOURCES				
33. In addition to the principle of ecological restoration, the landscape design embodies the principle of ethnographic landscape restoration and gives consideration to pertinent traditional native values.	○	●	●	●
34. Make the project area an important focal point of interpretation of history and culture of the Coast Miwok.	○	●●	●●	●●

Table Key:

○ Alternative does not meet the objective.

● to ●●● The relative degree to which the alternative meets the objective, with ●●● being the highest rating.

16. Engage visitors in the natural ecosystem and cultural heritage of the site.

Options B, C, and D present better opportunities than Option A – No Action, but not equally so. Option B would provide somewhat more engagement than Option A, Option C even more, and Option D the most. Two key indicators were identified for this objective:

a. Character and sequence of experience from vehicle to destination facilities.
   With Option A (No Action), visitors park at the large lot near the beach and proceed directly across the dunes to the beach. There is little indication of a transition from one place to another. Option B would locate all parking spaces near the beach, so the experience for the visitor would be similar to that of Option A. With the addition of a 50-space lot in the Alder Grove in Option C, the visitors who park at the Alder Grove lot would go through several habitats before arriving at the beach, so this would expand the sequential experience for some visitors. Option D would have almost all private vehicles parking at the Alder Grove lot, creating an expanded sequential experience from vehicle to destination for almost all visitors who park at the site.

b. Character and potential of interpretive opportunities.
   Interpretive opportunities would expand in direct proportion to the variety of the types of habitat and ethnographic/habitat links. All restoration alternatives would offer greater potential than the existing conditions. Each type of restored habitat would be meaningful by itself, and the relations among the types would also hold interest. Therefore, Options B, C, and D would be increasingly better than Option A.

17. Incorporate a broad spectrum of appropriate visitor experiences compatible with the resources of the site.

All three options (B, C, and D) would provide a greater variety and range of visitor experiences than would Option A. The perimeter loop trail would reduce conflicts with wildlife and create greater potential wildlife experiences. Interpretive opportunities along the trail would be more closely correlated with actual site conditions. The separation of trails from roadways would also minimize conflicts and improve visitors' experiences. The new riparian trail behind the Pelican Inn in Options C and D would give these two options a broader range of ecological experiences than Option B.

18. Provide convenient access to public use facilities for people of all ages and abilities.

Options B and C would provide more convenient access to the beach than the existing condition (Option A), while Option D would probably not improve conditions. Six key indicators were identified for this objective:

a. Relative distance from parking to beach, creek, wetlands, and trails.

The reconfigured lot of Option B and the beach lot of Option C would be in generally the same place as the existing lot, close to the beach with easy and direct access. Option C would move some parking to the Alder Grove, forcing some visitors to travel a greater distance (0.5 mi, instead of 0.1 mi) from the parking lot to the beach. Almost all visitors in Option D, except those arriving at the shuttle drop-off or in officially disabled-designated vehicles, would have to park half a mile away from the beach.

b. Relationship of access route to sensitive resources.

In all restoration alternatives and access options, the existing levee road would be removed and the access routes would be aligned at the periphery of the sensitive wetland habitats, currently bisected by the Levee Road. In each of Options C and D, a new trail would be proposed through the Alder Grove. The trail would be set back 100 feet from the creek and would follow the edges of existing disturbed areas. The trail, however, would impact existing riparian habitat. In Option B, the trail along Pacific Way would lie in the old creekbed, while the trail of Options C and D would follow alongside the road. Assuming a road width of 20 feet and a trail width of 8 feet, the new arrangement might remove some existing habitat where the existing road is narrower than 28 feet, but habitat adjacent to Pacific Way is likely to be already degraded. Finally, the trail designated as an emergency-access route in Options B, C, and D would be built on an existing trail that is already 12 feet wide, so the new trail would have minimal impact.

c. Extent of compliance with ADA guidelines.

The ADA guidelines govern several aspects of public access. Accessible routes must be at least 4 feet wide; they may have a slope no steeper than 5% before handrails are required, while cross-slopes may be no steeper than 2% in any case; they must have a durable hard surface, such as asphalt, aggregate base, concrete, or wood; and they must not be in conflict with vehicles. Option A (No Action) is non-compliant with respect to vehicular conflicts on the accessible route and surface materials. Options B and C would comply fully with ADA guidelines: all trails (including the loop trail) and parking facilities would be equally accessible to all users. Option D would be fully compliant, except for the 700-foot stretch of the loop trail that would extend along the beach; the inherent shifting of the sand would prevent this stretch of the internal loop from being paved in an ADA-compliant surface.

d. Extent project exceeds ADA guidelines for special-needs visitors.

Options B, C, and D would improve conditions for special-needs visitors over Option A to a similar degree. A varied interpretive program could also address special needs, such as by incorporating tactile displays for the visually impaired.

e. Consistency with CTMP recommendations for parking lot capacity, transit facilities, and trail linkages.
Options B and C could accommodate current parking demand and a portion of projected demand by meeting the existing peak parking demand and providing the facilities for parking, transit, and trail linkages. Option D could also improve transit facilities and trail linkages, but it would include fewer parking spaces than the existing peak demand according to the CTMP. In order to meet the existing demand, Option D would require simultaneous implementation of the transit improvements discussed in the CTMP

f. Number of parking spaces.
With the exception of Option A (No Action), each option has been presented with a range of parking capacity, rather than a single number. Option A has 175 spaces, Option B could have 90 to 200 spaces, Option C could have 140 to 200 spaces, and Option D could have 64 to 132 spaces. The current peak-season weekend demand, valid for about 12 days of the year, is 200 cars, and this figure is predicted to grow to 260 cars by 2023. But in the rest of the year, parking demand may be 160, 120, or even only 30 cars on off-season weekdays. Future (2023) demand is predicted to rise to 200 cars more often (peak-season weekdays and shoulder-season weekends), and minimal demand is predicted as 50 cars on off-season weekdays. Therefore, each option would satisfy the demand for parking on at least some days, and only Options B and C could satisfy the current maximum demand of 200 cars, but no option would satisfy all demand on all days.

19. Provide safe pedestrian access from parking/drop-off areas to public use destinations.

All three options would improve pedestrian safety over the No-Action option, but Options B and C would do somewhat more to provide safe access than would Option D. Four key indicators were identified for this objective:

a. Number and character of road crossings.
Trail crossings at roads in Option B would remain the same as those in Option A, while Options C and D would add a crossing, where the trail from the Alder Grove lot would cross Pacific Way. More visitors would be affected by this crossing in Option D than in Option C because of the relative sizes of the parking lots.

b. Relative amount of pedestrian traffic on Highway One.
Options B and C could provide enough parking capacity to satisfy existing parking demand, and thus minimize illegal parking of vehicles along Highway One and the resulting pedestrian use along this road. The reduced number of parking spaces in Option D might force illegal overflow parking onto Highway One and Muir Woods Road. If there were no satellite/shuttle options, there would likely be more pedestrian traffic on Highway One under Option D than under the No-Action option.

c. <u>Extent of trail separated from roadways.</u>
All trails in Options B, C, and D would be separated from the roads. This would be a significant improvement over Option A, in which Pacific Way is used as a trail link.

d. <u>Size and character of multi-use trails.</u>
The multi-use trails in all options would be designed with appropriate width (generally 8 to 12 feet) and surfacing (of a durable material not yet specified), and the variety of surrounding habitats would improve the character of trails over the existing condition.

20. Provide safe and continuous linkages between currently disconnected trails for all user groups.

All three options (B, C, and D) would provide fully accessible, multi-use links among the Coastal Trail, Diaz Ridge Trail, and Redwood Creek Trail. These new trail linkages would be separated from roadways, but designated road crossings at Pacific Way and/or Highway One would be required in all three options.

21. Provide safe vehicular access to the visitor resources.

Options B, C, and D would improve vehicular safety along Pacific Way with a combination of bridge widening, road reconstruction, and separation of trails from roads. Options C and D would add another intersection along Highway One, with the safety concerns accompanying turns onto a busy road. Option D would have the potential for greatest complexity, due to the use of the drop-off and remote parking. Five key indicators were identified for this objective:

a. <u>Intersection function/safety.</u>
The intersection of Pacific Way and Highway One would not change under Option B. The intersection of Pacific Way and Highway One could become somewhat less safe under Options C and D, because of the remote parking at the Alder Grove and the potential for "double-driving" (dropping off passengers at the beach, then returning to the Alder Grove to park). This potential would be highest under Option D, with most of the parking shifted away from the beach. In addition, a new intersection would be created along busy Highway One under Options C and D, with the intersection in Option D receiving higher volumes of traffic.

b. <u>Function/safety along Pacific Way.</u>
All three options would dramatically improve safety along Pacific Way. The new bridge would be wide enough to accommodate two lanes of traffic and a trail (the existing bridge allows only one lane, without a separate trail) and high enough over Redwood Creek to avoid the current problems with flooding. The redesigned road would discourage shoulder-parking with appropriate treatment of the edges, and would reduce the frequent traffic blockages.

c. <u>Proximity of parking access roads to intersection and view obstructions.</u>
Option B, and the beach lot in Option C, would not change the location of access roads or intersections from Option A. Options C and D would add an entry for parking access along Highway One, north of the Pelican Inn and near the intersection with Pacific Way.

d. <u>Reduction in need or potential to park on Highway One.</u>
As described in 19.b. above, Options B and C could provide enough capacity in parking lots to minimize parking on Highway One compared to Option A. Even with implementation of transit that could be a component of the CTMP, some vehicles might park on the highway anyway under Option D because of the reduced parking capacity. Without the off-site CTMP improvements, shoulder-parking on Highway One would probably increase under Option D, compared with the No-Action option.

e. <u>Number of vehicular circulation decision points.</u>
Option B would not change the number of decision points (intersections) from Option A. Options C and D would add a decision point off Highway One, at the entry/exit for the Alder Grove lot.

22. Minimize access conflicts between public visitors and residential users.

All three options (B, C, and D) would bring improvements over Option A, with Option C reducing conflicts the most. Along Pacific Way, rebuilding the bridge for two lanes of traffic, eliminating shoulder-parking, and separating pedestrians from the roadway would improve the current condition in all three options. The single large lots of Options B and D (at the existing lot's location and at the Alder Grove, respectively) would concentrate the visitors' parking near residential areas, while the two lots of Option C would slightly alleviate conflicts at the beach. The gate across Pacific Way in Option C would also reduce conflicts by keeping visitor traffic out of the residential area.

23. Minimize land-use conflicts between visitor access and adjacent uses.

Besides the residences of Muir Beach, uses adjacent to the project site include equestrian facilities, open space, agriculture, the Zen Learning Center, and the fire department. Options B and D would be about the same as Option A in minimizing conflicts, while Option C would be slightly better.

Three key indicators were identified for this objective:

a. <u>Compatibility of adjacent uses.</u>
Each option is compatible with adjacent uses to a degree roughly the same as Option A.

b. Proximity of parking.
   Parking lots would be either in the same place (at the beach, in Options B and C) or in a new place (the Alder Grove, in Options C and D). Splitting the parking lots in Option C would spread out the impacts of visitor access and improve the situation somewhat.

c. Character of linkages between uses.
   Linkages between uses would be similar in Options B, C, or D. Improving the network of trails would connect the project site more explicitly and safely to the Zen Center lands, to the dairy/stable, and to adjacent open space and existing trails.

24. Minimize conflicts between access and use of facilities and the natural function of the ecosystem.

All three options would greatly improve this condition, despite the potential for new multi-use trails to cause erosion or generate sediment.

Four key indicators were identified for this objective:

a. Number and type of stream crossings.
   Options B and C would include stream crossings at Pacific Way and by a footbridge from the parking lot, while Option D would include a crossing on Pacific Way and a long boardwalk directly between the parking lot/drop-off and the beach. All bridges would be built long enough to avoid impeding the watercourse below.

b. Proximity of sensitive habitats to access routes and use facilities.
   In Options B, C, and D, removing the levee road and keeping all human activities around the periphery of the site would allow the restored habitats of this ecosystem to flourish with minimal human conflicts. Access routes and use facilities would be kept away from sensitive habitats.

c. Extent of habitat connectivity.
   Habitat connectivity would improve in Options B, C, and D, as trails and use facilities would be located to avoid fragmentation. The current disconnection at the levee road would be repaired.

d. Extent that multi-use (pedestrian, bicycle, equestrian, etc.) trails are expected to cause erosion and sediment generation (due to steepness, use in the wet season, etc.).
   Trails in all options have the potential to cause erosion or generate sediment, but the site engineering and surfacing for these trails would be designed for durability and minimal erosion.

25. Provide emergency access through site.

Options B, C, and D would be similar in their effect, all slightly better than Option A because the emergency access would be less prone to flooding. Each option would feature emergency-access trails on both sides of the creek, each trail being at least 12’ wide and having an all-weather surface. On the east side of the creek, the trail would connect with an emergency staging area. Ease of emergency vehicle access to the beach and Coastal Trail south of the site would be about the same as in Option A, except in winter. The travel distance for emergency vehicles would be longer (worse) than Option A, because vehicles would not be able to use the levee road. Congestion along Pacific Way, the primary access route to the beach and residences, would be lower (better), with the widened road bridge and improved roadway to discourage shoulder parking.

26. Reduce noise and aesthetic/visual distraction of parking and maintain “rustic character”.

In all three options (B, C, and D), the new parking lots would dramatically increase the amount of shading and screening of the parking spaces, and would feature small parking bays, unlike the single vast parking lot of Option A. As for distance of parking from residents, the beach parking lots of Options B and C would be in generally the same place as Option A. The remote lots of Options C and D would be significantly farther from most residents, but closer to those few residents near the Alder Grove.

33. In addition to the principle of ecological restoration, the landscape design embodies the principle of ethnographic landscape restoration and gives consideration to pertinent traditional native values.

The three options would be similar in effect, and all slightly better than Option A. Each restoration alternative and public-access option would employ native plants with traditional Coast Miwok cultural uses in the human-impact zones as well as the restoration areas. The project team would also seek the support of the Federated Indians of the Graton Rancheria for input on cultural aspects of the design.

34. Make the project area an important focal point of interpretation of history and culture of the Coast Miwok.

Each restoration alternative and access option could improve over the current condition by providing interpretive media devoted to the Coast Miwok history and use of the area. Restoration Alternatives 3 and 4, with their more extensive open water and marsh habitats, could offer landscape opportunities closer to those of the era of Coast Miwok habitation and could give visitors deeper insight into the relationship of native peoples with this ecosystem.

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12. FIGURES

APPENDIX A

HYDRAULIC MODELING DATA

The one–dimensional hydrodynamic model MIKE 11 was used to model the various alternatives of the project restoration. Figures A1, A2, and A3 show the model setup for Alternatives 1, 2, and 4, respectively. Each alternative is comprised of main branch, various overbank flow paths, and linkages connecting the overbank flow paths to the main branch. One Figures A1, A2, and A3, the flow path labeled number 2 is the main branch, and flow paths 1 and 3 are the overbank paths.

The upstream boundary is either a hydrograph for the 5-year or 50-year flood. The downstream boundary is a constant water level set at mean higher high water (MHHW). In general, the roughness in the main channel is specified with a Manning n of 0.05 in the upper reaches and a Manning n of 0.03 through the sandier reach surrounded by sand dunes. The overbank areas have a Manning n of 0.07 to 0.10 depending on the relative amount of roughness and expected flow depth.

The hydraulic model does not include flows from the two Green Gulch tributaries (Green Gulch Creek and the unnamed tributary). At present, the hydrology of Green Gulch Creek is not well defined. The limited information available on Green Gulch flows (PWA et al., 1994; PWA et al., 2003) suggests that Green Gulch flows are not significant relative to flows on Redwood Creek.

The cross-sections for six hydraulic models (Alternatives 1, 2 and 4, at Year 0 and Year 50 each) will be provided to NPS as a technical appendix, separate from this report. The MIKE-11 model uses metric dimensions, while the feasibility study was in English units. In addition, for channel profiles provided in main body of the report, the channel is stationed in feet starting at the downstream end. For the MIKE-11 model, channel stationing is in meters, starting at the upstream end. Table A-1 provides the label and approximate stationing for the model sections shown on Figures A1 to A3.

At present, the hydraulic model is not calibrated due to the lack of data. In order to calibrate the hydraulic model, the following data sets spanning the same time period would be necessary:

- A time series of water level at the downstream boundary;
- A time series of stage and discharge at an intermediate point between the upstream boundary and the downstream boundary;
- A time series of discharge at the upstream boundary; and
- Peak water levels at various locations (i.e., along the levees and overbank areas).

In additional to the above, a spatial map identifying zones of vegetation and surficial bed material would be necessary to assign relative values of Mannings n. In the present study, this was achieved by identifying areas on the 2003 orthophoto (see Figure 2) and through field observations.

Table A-1. Cross-section Locations

Section Name	Figure Station[1] (ft)	MIKE 11 Station[2] (m)
A	3,759	73
B	3,493	155
C	3,260	226
D	2,966	315
E	2,753	380
F	2,627	419
G	2,427	480
H	2,292	521
I	2,090	582
J	1,933	630
K	1,819	665
L	1,663	713
M	1,560	744
N	1,389	757
O	1,287	827
P	1,098	885
Q	770	985
R	537	1056
S	353	1112

[1]Stationing for cross-sections shown in report figures based on existing channel stationing established by field surveys in 2003 by EDS.
[2]Stationing used in MIKE 11 hydraulic model.

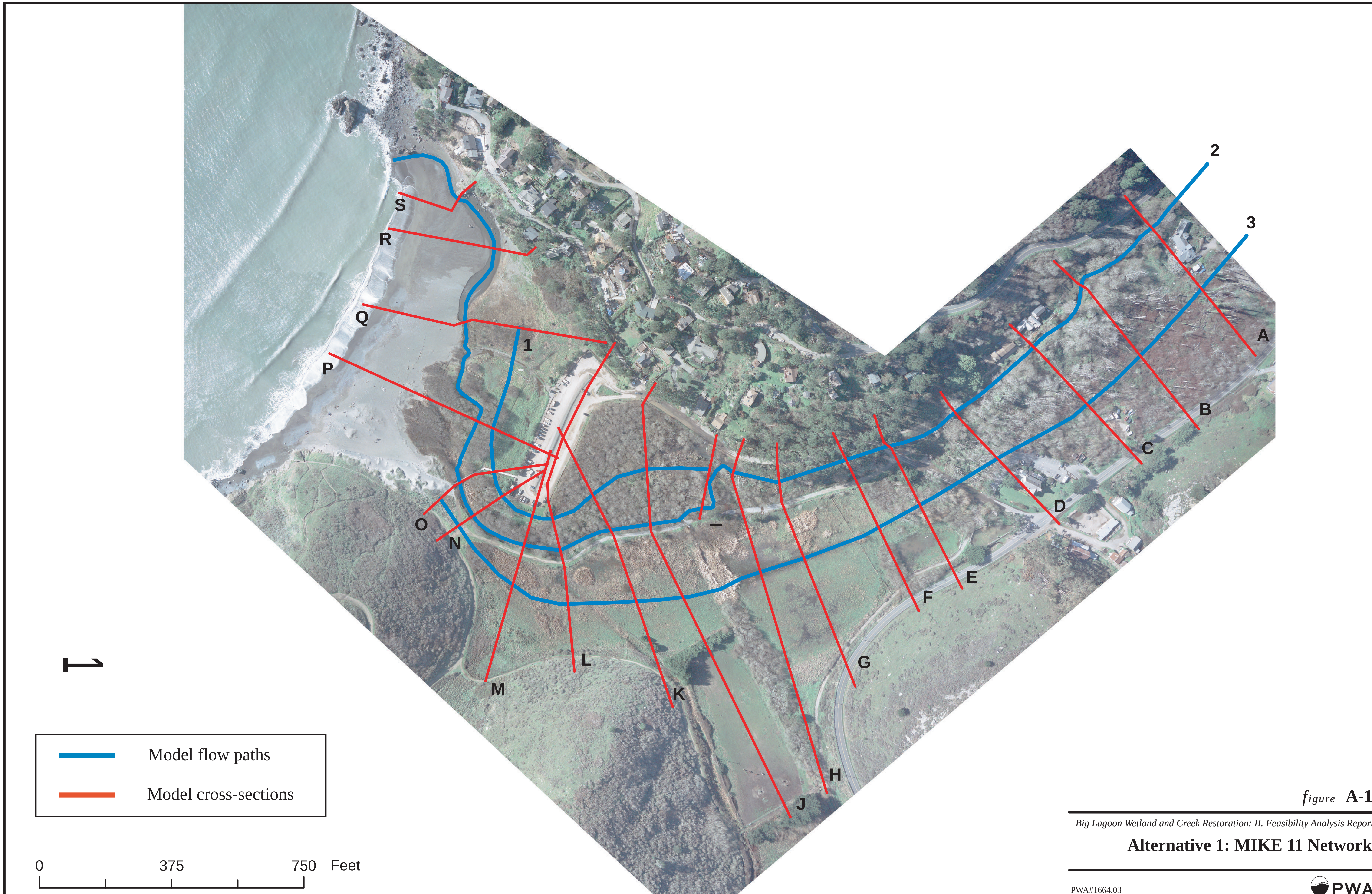

figure **A-1**

Big Lagoon Wetland and Creek Restoration: II. Feasibility Analysis Report

Alternative 1: MIKE 11 Network

PWA#1664.03

PWA

Model flow paths

Model cross-sections

0 375 750 Feet

figure **A-2**

Big Lagoon Wetland and Creek Restoration: II. Feasibility Analysis Report

Alternative 2: MIKE 11 Network

PWA#1664.03

PWA

Model flow paths

Model cross-sections

0 375 750 Feet

figure **A-3**

Big Lagoon Wetland and Creek Restoration: II. Feasibility Analysis Report

Alternative 4: MIKE 11 Network

PWA#1664.03

PWA

APPENDIX B

WATER BALANCE CALCULATIONS

Table B-1. Alternative 1 Water Balance

Month	Redwood Crk Avg. Flow (cfs)	Inflow Volume (ac-ft)	Unimpaired Flow Rate (cfs)	Unimpaired Inflow Vol. (ac-ft)	Open Water Evaporation Losses (ft)	Open Water Evaporation Losses (ac-ft)	Evapotranspiration Losses by Wetland plants (ft)	Evapotranspiration Losses by Wetland plants (ac-ft)	Drop in Water Level w/ Diversion (ft)	Drop in Water Level w/o Diversion (ft)
Mar. 92	14.51	874.93	14.58	879.15	0.16	0.38	0.20	3.00	0	0
Apr	3.54	213.23	3.61	217.45	0.22	0.53	0.28	4.20	0	0
May	0.93	56.33	1.00	60.55	0.32	0.77	0.40	6.00	0	0
Jun	1.20	72.39	1.27	76.61	0.37	0.89	0.46	6.90	0	0
Jul	0.29	17.28	0.36	21.50	0.43	1.03	0.54	8.10	0	0
Aug	0.12	7.33	0.19	11.55	0.33	0.79	0.41	6.15	0	0
Sep	0.04	2.70	0.11	6.92	0.23	0.55	0.29	4.35	-0.9	0
Oct	0.12	7.06	0.19	11.28	0.14	0.34	0.18	2.70	0	0
Nov	0.02	1.50	0.09	5.72	0.06	0.14	0.08	1.20	0	0
Dec	15.38	927.33	15.45	931.55	0.03	0.07	0.04	0.60	0	0
Jan 93	64.54	3891.80	64.61	3896.02	0.02	0.05	0.03	0.45	0	0
Feb	37.25	2245.91	37.32	2250.13	0.05	0.12	0.06	0.90	0	0
Mar	13.05	786.93	13.12	791.15	0.16	0.38	0.20	3.00	0	0
Apr	8.52	513.85	8.59	518.07	0.22	0.53	0.28	4.20	0	0
May	2.43	146.29	2.50	150.51	0.32	0.77	0.40	6.00	0	0
Jun	3.65	220.10	3.72	224.32	0.37	0.89	0.46	6.90	0	0
Jul	0.62	37.10	0.69	41.32	0.43	1.03	0.54	8.10	0	0
Aug	0.36	21.88	0.43	26.10	0.33	0.79	0.41	6.15	0	0
Sep	0.12	7.25	0.19	11.47	0.23	0.55	0.29	4.35	0	0

Table B-2. Alternative 2 Water Balance

Month	Redwood Crk Avg. Flow (cfs)	Inflow Volume (ac-ft)	Unimpaired Flow Rate (cfs)	Unimpaired Inflow Vol. (ac-ft)	Open Water Evaporation Losses		Evapotranspiration Losses by Wetland plants		Drop in Water Level w/ Diversion (ft)	Drop in Water Level w/o Diversion (ft)
					(ft)	(ac-ft)	(ft)	(ac-ft)		
Mar. 92	14.51	874.93	14.58	879.15	0.16	0.43	0.20	2.94	0	0
Apr	3.54	213.23	3.61	217.45	0.22	0.59	0.28	4.12	0	0
May	0.93	56.33	1.00	60.55	0.32	0.86	0.40	5.88	0	0
Jun	1.20	72.39	1.27	76.61	0.37	1.00	0.46	6.76	0	0
Jul	0.29	17.28	0.36	21.50	0.43	1.16	0.54	7.94	0	0
Aug	0.12	7.33	0.19	11.55	0.33	0.89	0.41	6.03	0	0
Sep	0.04	2.70	0.11	6.92	0.23	0.62	0.29	4.26	-0.8	0
Oct	0.12	7.06	0.19	11.28	0.14	0.38	0.18	2.65	0	0
Nov	0.02	1.50	0.09	5.72	0.06	0.16	0.08	1.18	0	0
Dec	15.38	927.33	15.45	931.55	0.03	0.08	0.04	0.59	0	0
Jan 93	64.54	3891.80	64.61	3896.02	0.02	0.05	0.03	0.44	0	0
Feb	37.25	2245.91	37.32	2250.13	0.05	0.14	0.06	0.88	0	0
Mar	13.05	786.93	13.12	791.15	0.16	0.43	0.20	2.94	0	0
Apr	8.52	513.85	8.59	518.07	0.22	0.59	0.28	4.12	0	0
May	2.43	146.29	2.50	150.51	0.32	0.86	0.40	5.88	0	0
Jun	3.65	220.10	3.72	224.32	0.37	1.00	0.46	6.76	0	0
Jul	0.62	37.10	0.69	41.32	0.43	1.16	0.54	7.94	0	0
Aug	0.36	21.88	0.43	26.10	0.33	0.89	0.41	6.03	0	0
Sep	0.12	7.25	0.19	11.47	0.23	0.62	0.29	4.26	0	0

Table B-3. Alternative 3 Water Balance

Month	Redwood Crk Avg. Flow (cfs)	Inflow Volume (ac-ft)	Unimpaired Flow Rate (cfs)	Unimpaired Inflow Vol. (ac-ft)	Open Water Evaporation Losses (ft)	Open Water Evaporation Losses (ac-ft)	Evapotranspiration Losses by Wetland plants (ft)	Evapotranspiration Losses by Wetland plants (ac-ft)	Drop in Water Level w/ Diversion (ft)	Drop in Water Level w/o Diversion (ft)
Mar. 92	14.51	874.93	14.58	879.15	0.16	1.42	0.20	1.70	0	0
Apr	3.54	213.23	3.61	217.45	0.22	1.96	0.28	2.38	0	0
May	0.93	56.33	1.00	60.55	0.32	2.85	0.40	3.40	0	0
Jun	1.20	72.39	1.27	76.61	0.37	3.29	0.46	3.91	0	0
Jul	0.29	17.28	0.36	21.50	0.43	3.83	0.54	4.59	0	0
Aug	0.12	7.33	0.19	11.55	0.33	2.94	0.41	3.49	0	0
Sep	0.04	2.70	0.11	6.92	0.23	2.05	0.29	2.47	-0.14	0
Oct	0.12	7.06	0.19	11.28	0.14	1.25	0.18	1.53	0	0
Nov	0.02	1.50	0.09	5.72	0.06	0.53	0.08	0.68	0	0
Dec	15.38	927.33	15.45	931.55	0.03	0.27	0.04	0.34	0	0
Jan 93	64.54	3891.80	64.61	3896.02	0.02	0.18	0.03	0.26	0	0
Feb	37.25	2245.91	37.32	2250.13	0.05	0.45	0.06	0.51	0	0
Mar	13.05	786.93	13.12	791.15	0.16	1.42	0.20	1.70	0	0
Apr	8.52	513.85	8.59	518.07	0.22	1.96	0.28	2.38	0	0
May	2.43	146.29	2.50	150.51	0.32	2.85	0.40	3.40	0	0
Jun	3.65	220.10	3.72	224.32	0.37	3.29	0.46	3.91	0	0
Jul	0.62	37.10	0.69	41.32	0.43	3.83	0.54	4.59	0	0
Aug	0.36	21.88	0.43	26.10	0.33	2.94	0.41	3.49	0	0
Sep	0.12	7.25	0.19	11.47	0.23	2.05	0.29	2.47	0	0

Table B-4. Alternative 4 Water Balance

Month	Redwood Crk Avg. Flow (cfs)	Inflow Volume (ac-ft)	Unimpaired Flow Rate (cfs)	Unimpaired Inflow Vol. (ac-ft)	Open Water Evaporation Losses (ft)	Open Water Evaporation Losses (ac-ft)	Evapotranspiration Losses by Wetland plants (ft)	Evapotranspiration Losses by Wetland plants (ac-ft)	Drop in Water Level w/ Diversion (ft)	Drop in Water Level w/o Diversion (ft)
Mar. 92	14.51	874.93	14.58	879.15	0.16	1.70	0.20	1.36	0	0
Apr	3.54	213.23	3.61	217.45	0.22	2.33	0.28	1.90	0	0
May	0.93	56.33	1.00	60.55	0.32	3.39	0.40	2.72	0	0
Jun	1.20	72.39	1.27	76.61	0.37	3.92	0.46	3.13	0	0
Jul	0.29	17.28	0.36	21.50	0.43	4.56	0.54	3.67	0	0
Aug	0.12	7.33	0.19	11.55	0.33	3.50	0.41	2.79	0	0
Sep	0.04	2.70	0.11	6.92	0.23	2.44	0.29	1.97	-0.13	0
Oct	0.12	7.06	0.19	11.28	0.14	1.48	0.18	1.22	0	0
Nov	0.02	1.50	0.09	5.72	0.06	0.64	0.08	0.54	0	0
Dec	15.38	927.33	15.45	931.55	0.03	0.32	0.04	0.27	0	0
Jan 93	64.54	3891.80	64.61	3896.02	0.02	0.21	0.03	0.20	0	0
Feb	37.25	2245.91	37.32	2250.13	0.05	0.53	0.06	0.41	0	0
Mar	13.05	786.93	13.12	791.15	0.16	1.70	0.20	1.36	0	0
Apr	8.52	513.85	8.59	518.07	0.22	2.33	0.28	1.90	0	0
May	2.43	146.29	2.50	150.51	0.32	3.39	0.40	2.72	0	0
Jun	3.65	220.10	3.72	224.32	0.37	3.92	0.46	3.13	0	0
Jul	0.62	37.10	0.69	41.32	0.43	4.56	0.54	3.67	0	0
Aug	0.36	21.88	0.43	26.10	0.33	3.50	0.41	2.79	0	0
Sep	0.12	7.25	0.19	11.47	0.23	2.44	0.29	1.97	0	0